Guidance for Solid Waste Beneficial Use Proposals

October 1998

Questions and Answers on Beneficial Use of Solid Waste

What does "beneficial use" mean?

Beneficial use means using a solid waste in a manufacturing process to make a product or as an effective substitute for materials used in a commercial product.

What statute governs the beneficial use of solid waste in CT?

Section 22a-209f of the Connecticut General Statutes allows the DEP to issue general permits for the beneficial use of a solid waste if the proposed use meets certain standards.

How does one find out whether a solid waste could qualify for beneficial use?

Contact the Waste Planning and Standards Division of the DEP Waste Management Bureau at 79 Elm Street, Hartford, CT 06106 (860 424-3365) to set up a meeting to discuss your proposal. At the meeting, DEP staff will review preliminary information about your proposal and identify additional information you need to supply so a full evaluation can take place.

What information should one bring to the first meeting at DEP?

At a minimum, you need to have a good idea of the chemical constituents of the solid waste you are proposing for reuse, the process by which that waste is generated, any additional processing the waste will undergo prior to reuse, and the nature of the proposed use and any information about the material's life cycle and/or potential environmental impacts. **The more detailed you can be at the first meeting, the more productive it will be.**

What will one learn from meeting with DEP?

DEP staff will indicate whether there is an existing authorization under which your waste can be beneficially used. If not, they will provide you with the beneficial use guidance document, describe the application and review process for a new beneficial use, and discuss with you what further waste characterizations and human health and environmental risk analyses, if any, you will need to provide as part of your application. The extensiveness of these characterizations and analyses will depend on the nature of the waste you are proposing for reuse and the manner in which you are proposing to reuse it. **A broad, unrestricted use of a waste will probably require more extensive characterization and analysis than a limited, controlled use.**

Why is the beneficial use guidance document so formidable?

The DEP worked with a citizens advisory committee to develop a document which would cover a large range of potential beneficial uses, including a "worst case" scenario (i.e., one in which the solid waste proposed for beneficial use could be broadly distributed throughout the environment). The guidance can be used by an applicant for a beneficial use to identify (1) constituents of the solid waste which may constrain how and where the material can be beneficially used or (2) further assessments which need to be undertaken to demonstrate that the constituents will not present a threat to public health and safety or the environment.

Are there standard testing procedures for conducting waste characterizations and risk

analyses?

Yes. These are outlined in the guidance document, and DEP/DPH staff can provide you with this information when you come to the first meeting. If you do not have expertise in waste characterization or risk assessment, a consultant with environmental engineering and toxicology/ecotoxicology/risk assessment training can help.

Can other methods be proposed for characterizing the material proposed for reuse?

Yes. The DEP will consider other approaches if you can demonstrate that they are more appropriate for the waste material and the uses you are proposing provided that it yields reliable data which is representative of the beneficially used material.

When should an application for beneficial use be submitted?

An application on forms provided by the Commissioner should be submitted after you have met with the DEP staff and completed the characterizations and analyses required for DEP to review the proposed beneficial use.

What will DEP review in evaluating an application in addition to the characterizations of the material and the environmental and health risks of the proposed use?

At a minimum, DEP will require the following information:

1) assurance that you have reduced the toxicity and quantity of the solid waste as much as possible before proposing its beneficial use (This is consistent with the state's commitment to source reduction.);
2) a detailed narrative and schematic diagram of the production, manufacturing and/or residue process by which the solid waste that will be beneficially used is generated;
3) a detailed description or evaluation of how the solid waste will be processed, manufactured and or otherwise incorporated into a material for beneficial use addressing potential impacts on potable ground water resources, surface water resources and long-term human health exposure; and
4) a demonstration that a sufficient or probable market exists for the material proposed for beneficial use.

Will the DEP compare the environmental and health impacts of the proposed use to those of the material/product for which the solid waste is proposed to be substituted?

If the applicant provides this information, the DEP will consider it, but the DEP's primary consideration will be whether the solid waste beneficially used as proposed will be protective of human health and the environment.

What kind of permit would be issued?

The permit for beneficially using the waste will probably be a general permit available to anyone who can meet the permit requirements. A registration for the beneficial use by each person who wants to use the material may or may not be required depending on the nature of the waste and the proposed use. The facility which processes the solid waste for beneficial use may require either a general permit and a registration or an individual permit, again depending on the nature of the waste and the proposed use.

How long can one expect the process to take?

The process could take several months to more than a year. This depends largely on the quality of information you submit for DEP review and the rapidity with which you submit it. It also depends on the availability of DEP/DPH staff resource.

This guidance document contains the information necessary for the Connecticut Department of Environmental Protection (CT DEP) to review and evaluate a solid waste beneficial use proposal to determine if the proposal is appropriate and consistent with the statutory, regulatory requirements and the policies of the State. **Before completing the following information, it is recommended that the applicant meet with CT DEP to discuss each specific solid waste beneficial use proposal.** Requirements for data submissions will vary for the various types of solid wastes and/or for the processing categories. The scope of the proposed use will also affect the type of characterization required and whether a health and/or ecological risk assessment will be necessary. For example, a broad, unrestricted use of a material will require more extensive testing and analysis than a specific use where the destination of the material is known. **The CT DEP strongly recommends that a characterization plan be prepared for the review and comment by appropriate DEP staff prior to performing any sampling and analyses.**

Section 22a-209f of the CGS authorizes the CT DEP to issue general permits for categories of processing or beneficial use of solid waste when used in a manufacturing process to make a product or as an effective substitute for a commercial product. When found appropriate, a beneficial use authorization can be granted by DEP by incorporating specific controls through the issuance of an individual permit(s) and/or through the issuance of beneficial use general permits.

Part I: Applicant Information

The following list of information constitutes the minimum requirements for the CT DEP to evaluate a solid waste beneficial use proposal. Please fully complete the information requested. Print or type unless otherwise noted.

A. Legal name, address, and telephone number of the applicant. If the applicant is a corporation or a limited partnership transacting business in Connecticut, provide the exact name as registered with the Connecticut Secretary of the State.

B. Legal name, address, and telephone number of the applicant's primary contact for departmental correspondence and inquiries and of the applicant’s attorney or other representative, if applicable.

C. Address or site(s) of origin of the solid waste proposed for beneficial use.

D. A detailed description of the proposed type of beneficial use and/or processing activity to be covered by the general permit, a description of the process by which the solid waste is generated, and a demonstration that the generator has minimized the quantity and toxicity of the solid waste proposed for beneficial use to the greatest possible extent. Provide a detailed narrative and schematic diagram of the production, manufacturing and/or residue process by which the solid waste that will be beneficially used is generated.

E. A detailed description and full characterization of the solid waste proposed for beneficial use and of the end use material containing solid waste proposed for beneficial use including:
(1) A representative sampling program pursuant to a section of “Test Methods for Evaluating Solid Waste: Physical/Chemical Methods,” SW-846, U.S. Environmental Protection Agency, Office of Solid Waste, Washington, D.C. 20460";
(2) Verification that the sampling method has included all constituents present in the

solid waste;
(3) A detailed written report describing the concentration and distribution of all substances which maybe contained in the solid waste.

F. A detailed description of how the solid waste will be processed, manufactured and/or otherwise incorporated into a material for beneficial use.

G. A detailed description of how the solid waste will be handled and stored before and after it is processed.

H. A detailed evaluation of potential human health and environmental impacts from the proposed beneficial use of the solid waste containing material, including the potential risks to human health and ecological receptors that may result from the processing, manufacturing, or reuse of the solid waste, and the environmental impacts of the proposed beneficial use on the quality of ground water and surface water, soil, sediment and air.

I. A demonstration that a sufficient or probable market exists for the material proposed for beneficial use. Provide one or more of the following: a demonstration that the proposed material complies with industry standards and specifications for the proposed beneficial use; a description of the intended or probable markets and the existing demand for the proposed material with a demonstration (such as a contract or letter of intent) that sufficient capacity is or may be available to reasonably utilize the proposed material produced.

J. The signature of the applicant and of the individual or individuals responsible for actually preparing the information and supporting data submitted with the application, each of whom shall certify in writing as follows:

"I have personally examined and am familiar with the information submitted in this document and all attachments thereto, and I certify that, based on reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, the submitted information is true, accurate and complete to the best of my knowledge and belief. I understand that a false statement made in the submitted information may be punishable as a criminal offense, in accordance with Section 22a-6 of the General Statutes, pursuant to Section 53a-157b of the General Statutes, and in accordance with any other applicable statute."

K. Any other information the Commissioner may require or the applicant believes will demonstrate that the solid waste proposed for beneficial use will conserve, improve and protect natural resources and the environment and control air, land and water pollution in order to enhance the health, safety and welfare for the people of the state.

Part II: Where to File:

An application may be filed with the Commissioner at the following address:

BUREAU OF WASTE MANAGEMENT
OFFICE OF THE BUREAU CHIEF
DEPARTMENT OF ENVIRONMENTAL PROTECTION

79 ELM STREET
HARTFORD CT 06106-512

Understanding the chemical and physical properties of a solid waste

A well-developed plan for characterizing a solid waste proposed for beneficial use is a crucial step to identifying and acquiring the necessary data to thoroughly evaluate the physical and chemical properties of the waste and its potential human health and environmental impacts. While the discussion which follows focuses on the type of data needed to understand the physical and chemical properties of a solid waste, it is important that the plan reflect a clear understanding of the processes that generated the solid waste, and how such wastes are managed. When developing such a plan, it is important to consider the following questions:

- What are the physical and chemical characteristics of the materials and processes which generated the solid waste?
- How is the solid waste currently stored, handled and disposed?
- What are the proposed beneficial uses of the solid waste?
- How would the solid waste be stored, handled, processed and prepared for beneficial use?
- What are the physical and chemical characteristics of the solid waste after it has been processed and prepared for beneficial use?
- If the solid waste is to be used as a replacement for a geologic aggregate or other material in a manufactured product, what are the physical and chemical properties of that product prior to the substitution with the solid waste?

In some cases information may be readily available which would address some of these questions. Therefore, before preparing a characterization plan, a meeting with DEP staff is strongly encouraged to discuss the type of existing information which may be used, and what additional information may need to be obtained

A complete and sufficient characterization plan should describe the methods for sample collection and analysis, and demonstrate that the characterization will be representative of the solid waste. The following question and answer format may provide some guidance in preparation for meetings with DEP staff and aid in the development of a plan which would provide a representative characterization of a solid waste, before or after processing, which is proposed for beneficial use:

1. How will samples be collected (i.e., location, time of collection)?
2. What types of samples will be collected (i.e. discrete, grab, composite, continuous composite)?
3. What substances are present in the solid waste?
4. What type of physical and chemical analyses should be performed?
5. What is the variability of the substances present in the solid waste?
6. How many samples would need to be collected to develop the 95% upper confidence level?
7. What are the human health and ecological exposure pathways associated with beneficially using the solid waste in the manner proposed?

1. How will samples be collected (i.e., location, time of collection)?

Collection of samples must consider the nature of the activities generating the solid waste and how such waste is processed for the proposed beneficial use. If these activities undergo periodic changes (i.e. seasonal variation, changes in source materials, etc.), the sampling must be representative of such changing conditions. It is important to note that the concept of averaging should be carefully applied. It is not appropriate to combine or average sample data on the chemical characteristics of a solid waste if there is a seasonal or similar variability in the overall quality of the solid waste to be processed for re-use. For example, if a solid waste were characterized during a time when there was a tendency for lead concentrations to be low, the data would not be representative of lead concentrations if it is known that higher lead concentrations are likely to occur during another period of time.

2. What types of samples will be collected (i.e. discrete, grab, composite, continuous composite)?

Data which is to be used for the purposes of assessing human health and ecological exposure risks are usually based on the collection and analysis of discrete samples. Data from the analyses of composite samples are generally not appropriate for the statistical analyses employed in human health and ecological risk assessments because they mask the true variability of the solid waste. However, DEP staff may consider a proposal for a composite sampling protocol and an approach to using the resultant data for evaluating human health and ecological direct exposure risks. Such a proposal would need to well developed and be capable of demonstrating that the data would yield a representative characterization of the solid waste and account for any inherent variability in the substances which may be present. A composite sampling approach may be considered when evaluating impacts to water quality due to mobility of a substance.

3. What substances are present in the solid waste?

An understanding of the nature of the materials used in a process generating a solid waste can be very helpful in identifying what substances may be present. In circumstances where little information is available about the source or the generation of the solid waste, it may be necessary to perform an initial, broad-based screening to determine the possible substances which may be present. The substances identified from available information or from an initial screening would form the basis for determining the types of analyses which need to be performed on the collected samples.

4.**What type of physical and chemical analyses should be performed?**

There are essentially three categories of analyses which may need to be performed to properly characterize a solid waste before or after processing: physical, total mass, and leachability. Physical analyses may be needed to determine whether a beneficially used solid meets its required performance specifications. Both total mass and leachability analyses are usually necessary as part of any characterization plan. Results from total mass analyses are used to evaluate direct human and ecological exposures to substances present in a solid waste. Results from leachability analyses are used to evaluate the mobility of substances present in a solid waste and their potential water quality impacts to drinking water supplies and aquatic ecosystems.

5. What is the variability of the substances present in the solid waste?

As discussed earlier, characterizing the variability of the quality of a solid waste requires careful planning for sample collection and analyses. Using the data from these analyses, statistical methods can help characterize the variability of pollutant concentrations present in a solid waste with a relatively small sample population. The 95% upper confidence limit (95% UCL) of the arithmetic mean for each substance is a statistical approach to providing a reasonably conservative estimate of the upper limit of the average concentrations of each substance analyzed in the solid waste.

6. **How many samples would need to be collected to develop the 95% upper confidence level?**

To develop the 95% UCL of the arithmetic mean for each substance of concern, a determination must be made on the appropriate number of discrete samples which must be collected. Guidance on defining the appropriate number of samples can be found in Chapter 9 of EPA's publication SW-846 entitled, "Test Methods for Evaluating Solid Waste" According to another EPA publication entitled, Supplemental Guidance to RAGS: Calculating the Concentration Term, sampling data from Superfund sites have shown that data sets with fewer than 10 samples per exposure area provide poor estimates of the mean concentration (i.e., there is a large difference between the sample mean and the 95% UCL), while data sets with up to 10 to 20 samples per exposure area provide somewhat better estimates of the mean, and data sets with 20 to 30 samples provide fairly consistent estimates of the mean (i.e., the 95% UCL is close to the sample mean). To develop a statistically representative characterization of a solid waste proposed for beneficial use, Department staff believe that a minimum of twenty (20) discrete samples would be necessary to characterize a waste generated from a specific facility. If the solid waste to be beneficially used were generated at more than one facility, twenty (20) discrete samples would be required from each facility waste stream.

7. What are the human health and ecological risks associated with beneficially using the solid waste in the manner proposed?

Once a representative characterization of the solid waste has been compiled and demonstrated to be complete and sufficient. The resulting information can be evaluated with respect to human health and ecological risks.

The following sections discuss the approaches for conducting these evaluation.

Human Health Risk Assessment (HHRA) Guidance for Beneficial Use

Waste reutilization in a beneficial use context may lead to exposure of workers or the public to toxic constituents originally present in the waste. This may occur during processing of the waste, application of the waste-containing product, or due to environmental releases from weathering and various transport processes. Such potential exposure pathways need to be evaluated to ensure that waste materials are not used in a manner which would increase human health risks to an unacceptable degree.

To address this concern, the Department of Public Health, Division of Environmental Epidemiology and Occupational Health (EEOH) has developed HHRA guidance for beneficial use submissions. The HHRA guidance represents a phased approach in which minimal effort is required to screen the acceptability of certain types of wastes/applications, but with more analysis needed if the initial screening process does not suffice.

The following steps outline the phased approach recommended for HHRA for beneficial use. Steps 1 and 2 describe the initial screening level portion of the HHRA. These steps may provide sufficient

1. Description of Scenarios Involving the Potential for Human Exposure

The processing, application/use, and eventual environmental fate of the waste should be described from the context of the potential for releases of toxic constituents into the environment. All relevant fate and transport processes should be considered. Exposure pathways involving workers and the general public should be identified with those representing the greatest potential for exposure discussed in terms of how constituents reach receptors, which media would be affected (i.e., would receptors contact affected air, water, soil, or waste product directly), and which exposure mechanisms would be involved (ingestion, dermal uptake, inhalation, etc.).

2. Comparison of Constituent Concentrations in the Use Product to Screening Target Concentrations

EEOH has developed a table of screening target concentrations (STCs) for the evaluation of constituent concentrations in the use product. STCs are provided in the attached tables together with an outline of the methods and equations used to derive the STCs. The tables assume that the major pathway for human exposure will occur once the use product has been applied or released into soil, or leached from soil into groundwater. STCs are to be compared against 95% upper confidence limit concentrations in the use product (or its leachate for groundwater STCs), without factoring in any dilution or degredation that might occur via fate and transport processes. While these factors typically decrease exposure, other factors which tend to increase risk (e.g., aggregating risks across multiple chemicals, exposure routes, release mechanisms) are also not included in this STC analysis. Thus, the STC comparison step represents a simple screening level approach to determine which reuse products need a more refined risk analysis. Given that STCs are risk-based, they do not take into account analytical limits of detection or background concentrations of constituents in soil or groundwater. Applicants can submit analytical limit of detection data and background data to provide additional perspective on constituent concentrations in the use product. The use product 95% UCL concentrations compared against STCs are to be based upon sufficient and representative sampling so as to comply with CT DEP requirements for characterization of the waste stream or use product.

STCs have been developed as initial screening for a wide variety of applications and products, some of which may be used with little restriction across the state. This type of use creates the possibility that moving from one residence to another will not end exposure to constituents in the use product. Therefore, the 70 rather than 30 year exposure period was chosen as the default exposure duration.

The STC tables are not necessarily inclusive of all constituents in a waste material for which EEOH could have a health concern. It is up to the applicant to either document that there are no additional constituents of potential concern, or if such constituents do exist, to develop STCs for them according to the procedures shown in the attachment.

If concentrations in the waste or product are uniformly below the STCs, this does not necessarily mean that there are no human risks of potential concern. Step 3 identifies conditions under which the STC approach is not sufficient by itself and further analysis is needed to more completely describe human risks.

3. Determination of Whether Additional Analysis is Necessary

The following are conditions under which a more detailed HHRA might be performed.

A. *Exceedance of STCs*: STCs provide a conservative frame of reference in that use product constituent concentrations are compared directly against STCs without factoring in dilution that might occur through transport processes. If STCs are exceeded, the applicant has the option of deriving exposure point concentrations (EPCs) to which human receptors may be exposed by performing realistic but conservative fate and transport modeling (see Step 4). These EPCs would then be used in assessing the potential risks from direct exposure (combination of soil ingestion and absorption across skin) to the affected media using the equations and risk targets described in this attachment.

B. *Presence of Bioaccumulative Compounds*: Simple comparison of analyte concentrations in the use product to STCs is not sufficient for strongly bioaccumulative constituents. The STC tables footnote several bioaccumulative constituents (e.g., PCBs, mercury, dioxins, furans, and chlorinated pesticides); novel constituents of the waste (i.e., those that do not appear on the STC tables) should be evaluated in terms of bioaccumulative potential. If bioaccumulative constituents are present in a use product, a multi-pathway risk assessment is needed to evaluate exposures and risks from the combined effects of direct (e.g., soil ingestion, skin absorption) and indirect (e.g., food chain) pathways. The procedure for conducting this type of assessment is outlined under Step 4.

C. *Other Pathways of Concern*: STCs are meant to be protective of residential exposure to constituents in the use product from direct ingestion or from leaching into groundwater. However, if use scenarios could involve other potentially more significant routes for human exposure (e.g., if waste product to be used in consumer products, indoors, other microenvironments, worker exposures), these scenarios should be described and quantitatively evaluated. This assessment may require fate and transport modeling and multi-pathway analysis as described below, or novel approaches to exposure modeling, depending upon the specific scenarios and chemicals involved.

4. Conduct of Multi-Pathway Risk Assessment

Contaminant transport modeling and multi-pathway risk assessment for use constituents involves the procedures outlined below. Prior to the conduct of the multi-pathway risk assessment, submission of a risk assessment protocol is strongly recommended for EEOH review. The protocol should be specific to the product intended uses, describing exposure scenarios and pathways, and presenting equations and parameter values planned for use in transport and exposure models. EEOH will provide comments in response to the protocol to facilitate the assessment process in a timely fashion.

A. Adhere to the 4 basic elements of human health risk assessment (hazard identification, exposure assessment, toxicity assessment, risk characterization) as described in USEPA's Risk Assessment Guidance for Superfund (1989) and subsequent updates.

B. Exposure Assessment
- Begin with 95% UCL concs. of constituents in waste material or use product;
- Perform fate and transport modeling to simulate distribution of constituents into the environment and develop EPCs in affected media; USEPA guidance documents[1] are to be relied upon as primary basis for transport modeling and EPC calculations; however, USEPA/Office of Solid Waste can be contacted (703-308-8855 or 8895) to determine if recent exposure/risk assessments have been conducted by that office that would serve as suitable precedent for the scenarios being analyzed by the applicant.
- Include all relevant release mechanisms that could occur during the processing,

storage, application, repair, or weathering of the use product; include an assessment of extreme scenarios (e.g., road washout into a stream bed for a use product going into road subsurface); exclusion of any potential release scenarios from the quantitative analysis should be explained and justified.

- Calculate EPCs in all affected media for all transported chemicals; NOTE: even though only some constituents may be highly bioaccumulative, the multi-pathway risk assessment should include exposure and risk analysis for all constituents. Calculations for abiotic media should include soil (from aerial deposition, runoff, erosion, etc.), groundwater (from leaching), and surface water (from aerial deposition, runoff, erosion, etc.);
- Model uptake into food chain from affected soil, water, sediment; include uptake into edible plants/produce/forage crops, beef and dairy, poultry and eggs, and fish;

[1] Relevant USEPA Guidance Documents are: Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions; EPA/600/6-90/003; 1990; Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions; EPA/600/AP- 93/003; 1993; Implementation Guidance for Conducting Indirect Exposure Analysis at RCRA Combustion Units; April, 1994

A. Risk Characterization

- Calculate human exposures and risks for residential scenario separately for each of the following exposure routes: soil ingestion, dermal contact with soil, ingestion of affected drinking water, ingestion of garden produce, ingestion of homegrown beef/poultry/eggs/dairy, and fish consumption from a local waterbody;
- Calculate aggregate risks for any given receptor according to USEPA guidance as follows: summing cancer risks for any exposure pathway across all carcinogens to which a given receptor is exposed; summing non-cancer risks across all non-carcinogens which have a similar target organ or mechanism of action; summing across exposure pathways to which a single receptor could reasonably be exposed (e.g., for residential scenario sum risks from soil ingestion, dermal absorption, ingestion of affected groundwater; ingestion of home-grown produce; if use product is intended to be used in unrestricted fashion across state, also add locally-grown beef, poultry, eggs, dairy, and locally caught fish);
- Calculate aggregate risks for a given receptor across different exposure age groups (e.g., 0-6 plus 7-30 years of age);
- Calculate risks separately for each release mechanism; however, if product use will be widespread and unrestricted, sum media concentrations, exposures and risks across release mechanisms that could lead to cumulative contamination of environmental media (e.g., add soil concentrations from aerial deposition from processing facility *to* soil concentrations from erosion/runoff from storage piles *to* soil concentrations resulting from weathering of product once applied);

NOTE: the risk assessment protocol should specify which exposure pathways and release mechanisms will be summed for a given product use; EEOH will provide feedback regarding risk aggregation and other aspects of the protocol prior to the conduct of the multi-pathway risk assessment.

- Calculate aggregate risks for any novel exposure pathways that might be relevant (see Step 3.C) and for workers exposed during processing, application, or repair of the use product;
- Compare aggregate risks for each receptor/scenario to aggregate risk targets (1E-06

cumulative cancer risk; HI of 1); if risk targets are not met, applicant has the option to describe any use restrictions or control measures that would reduce risks; these risk reductions should be described quantitatively to the extent possible.

- If dioxin or dioxin-like compounds are part of the analysis, the degree of aggregate exposure possible from the use product should be described relative to the background degree of exposure (body burdens) in the general population; the potential for background plus use-related exposures to yield elevated dioxins risks should be considered. Estimates of background dioxin exposure levels should be based upon established methods for estimating dioxin exposure (e.g., human body burden in combination with dioxin clearance rate to estimate daily intake - see USEPA, 1994: Estimating Exposure to Dioxin-Like Compounds, Vol.II: Properties, Sources, Occurrence and Background Exposures, EPA/600/6-88/005Cb) and submitted as part of the multi-pathway risk assessment protocol.
- For lead in soil, the degree of risk from use scenarios should be calculated for children by use of USEPA's Lead Integrated Exposure and Uptake Biokinetic Model; the model should be run by adding the use-related increment in soil exposure to the model's default background soil concentration and using the model's default conditions for other background exposure sources of lead.
- Uncertainty Analysis: risk characterization should include a discussion of the major uncertainties in the assessment and how such uncertainties, variability in input data, or assumptions used may tend to overestimate or underestimate risks. Sensitivity analysis can be used to determine the effects of particularly uncertain transport and exposure parameters on the overall results.

5. HHRA Submittal

The applicant should submit any analyses performed to fulfill the steps outlined above. Thus, even in cases where a multi-pathway risk assessment is necessary (Step 4), the analyses that led to its conduct (Steps 1 thru 3) should also be presented.

Waste Reuse Screening Target Concentrations: Direct Residential Exposure

Carcinogens:

RISK = CSF x DOSE

DOSE = STC x (EXPOSURE CHILD + EXPOSURE ADULT)

STC = RISK x 1/CSF / [(IRc x EF x EDc x CF / BWc x AT) + (IRa x EF x Eda x CF/B Wa x AT)]

Non-carcinogens:

HI_DOSE/Rfd

DOSE= STC x (EXPOSURE CHILD + EXPOSURE ADULT)

STC – RfD x HI/ [(IRc x EF x EDc x CF/BWc x ATc) + (IRa x EF x EDa x CF/B Wa x ATa)]

Waste Reuse Screening Target Concentrations: Direct Residential Exposure

Carcinogens:
RISK = CSF x DOSE

DOSE = STC x (EXPOSURE CHILD + EXPOSURE ADULT)

STC = RISK x 1/CSF / [(IRc x EF x EDc x CF / BWc x AT) + (IRa x EF x EDa x CF/BWa x AT)]

Non-carcinogens:
HI = DOSE/RfD

DOSE = STC x (EXPOSURE CHILD + EXPOSURE ADULT)

STC = RfD x HI/ [(IRc x EF x EDc x CF/BWc x ATc) + (IRa x EF x EDa x CF/BWa x ATa)]

Character		Description	Units	Value
STC	=	Screening Target Concentration	mg/kg	calculated
IRc	=	Ingestion Rate Child	mg/day	200
IRa	=	Ingestion Rate Adult	mg/day	100
EF	=	Exposure Frequency	days/year	365
EDc	=	Exposure Duration Child	years	6
EDa	=	Exposure Duration Adult	years	64
CF	=	Conversion Factor	kg/mg	0.000001
CSF	=	Cancer Slope Factor (oral)	(mg/kg-day)-1	chem-spec.
RfD	=	Reference Dose (oral)	mg/kg-day	chem-spec.
BWc	=	Body Weight Child	kg	15
BWa	=	Body Weight Adult	kg	70
AT	=	Averaging Time Carcinogens	days	25550
ATc	=	Averaging Time Non-carcinogens Child	days	2190
ATa	=	Averaging Time Non-carcinogens Adult	days	23360
RISK	=	Target Cancer Risk Level	unitless	5.0E-07
HI	=	Hazard Index	unitless	1.0

Source for exposure parameter values: USEPA Exposure Factors Handbook, 1989

Table 1. Screening Target Concentrations (STCs) for Waste Reuse

Chemical	CAS #	RfD	Carcinogen Class	CSF	STC (mg/kg)	Refs & Notes
Volatile Organic Compounds						
Acetone	67-64-1	1.0e-01	D		5.0e+02	1a
Acrylonitrile	107-13-1		B1	5.4e-01	3.8e-01	1
Benzene	71-43-2		A	2.9e-02	7.0e+00	1
Bromoform	75-25-2	2.0e-02	B2	7.9e-03	2.6e+01	1
2-Butanone (MEK)	78-93-3	6.0e-01	D		5.0e+02	1a
Carbon tetrachloride	56-23-5	7.0e-04	B2	1.3e-01	1.6e+00	1
Chlorobenzene	108-90-7	2.0e-02	D		5.0e+02	1a
Chloroform	67-66-3	1.0e-02	B2	6.1e-03	3.3e+01	1
Dibromochloromethane	124-48-1	2.0e-02	C	8.4e-02	2.4e+00	1
1,2-Dichlorobenzene	95-50-1	9.0e-02	D		5.0e+02	1a
1,3-Dichlorobenzene	541-73-1	9.0e-02	D		5.0e+02	4a
1,4-Dichlorobenzene	106-46-7	1.0e-01	B2/C	2.4e-02	8.5e+00	23
1,1-Dichloroethane	75-34-3	1.0e-01	C		5.0e+02	2a
1,2-Dichloroethane	107-06-2		B2	9.1e-02	2.2e+00	1
1,1-Dichloroethylene	75-35-4	9.0e-03	C	6.0e-01	3.4e-01	1
cis-1,2-Dichloroethylene	156-59-2	1.0e-02	D		5.0e+02	1,2a
trans-1,2-Dichloroethylene	156-60-5	2.0e-02	D		5.0e+02	1,2a
1,2-Dichloropropane	78-87-5	3.7e-04	B2	6.8e-02	3.0e+00	2
1,3-Dichloropropene	542-75-6	3.0e-04	B2	1.8e-01	1.1e+00	12
Ethylbenzene	100-41-4	1.0e-01	D		5.0e+02	1a
Ethylene dibromide (EDB)	106-93-4		B2	8.5e+01	2.4e-03	1
Methyl-t-butyl-ether (MTBE)	1634-04-4	5.0e-03			3.4e+02	4
Methyl isobutyl ketone	108-10-1	8.0e-02			5.0e+02	2a
Methylene chloride	75-09-2	6.0e-02	B2	7.5e-03	2.7e+01	1
Styrene	100-42-5	2.0e-01			5.0e+02	1a
1,1,1,2-Tetrachloroethane	630-20-6	3.0e-02	C	2.6e-02	7.9e+00	1
1,1,2,2-Tetrachloroethane	79-34-5		C	2.0e-01	1.0e+00	1
Tetrachloroethylene	127-18-4	1.0e-02	C-B2	5.2e-02	3.9e+00	14
Toluene	108-88-3	2.0e-01	D		5.0e+02	2a
1,1,1-Trichloroethane	71-55-6	3.5e-02	D		5.0e+02	4a
1,1,2-Trichloroethane	79-00-5	4.0e-03	C	5.7e-02	3.6e+00	1
Trichloroethylene	79-01-6	6.0e-03	C-B2	1.1e-02	1.9e+01	4b
Vinyl chloride	75-01-4		A	1.9e+00	1.1e-01	2
Xylenes	1330-20-7	2.0e+00	D		5.0e+02	1a
Semivolatile Organic Compounds						
Acenaphthene	83-32-9	6.0e-02	D		1.0e+03	1a
Acenaphthylene	208-96-8	6.0e-02	D		1.0e+03	1a,c
Anthracene	120-12-7	3.0e-01	D		1.0e+03	1a
Benzidine	92-87-5	3.0e-03	A	2.3e+02	8.9e-04	1
Benz(a)anthracene	56-55-3		B2	7.3e-01	2.8e-01	4
Benzo(b)fluoranthene	205-99-2		B2	7.3e-01	2.8e-01	4
Benzo(k)fluoranthene	207-08-9		B2	7.3e-02	2.8e+00	4
Benzo(a)pyrene	50-32-8		B2	7.3e+00	2.8e-02	1

Chemical	CAS #	RfD	Carcinogen Class	CSF	STC (mg/kg)	Refs & Notes
Bis(2-chloroethyl)ether	111-44-4		B2	1.1e+00	1.9e-01	1
Bis(2-chloroisopropyl)ether	39638-32-9	4.0e-02	C	7.0e-02	2.9e+00	12
Bis (2-ethyl hexyl)phthalate	117-81-7	2.0e-02	B2	1.4e-02	1.5e+01	1
Butyl benzyl phthalate	85-68-7	2.0e-01	C		1.0e+03	1a
2-Chloronaphthalene	91-58-7	8.0e-02			1.0e+03	1a
2-Chlorophenol	95-57-8	5.0e-03			3.4e+02	1
Chyrsene	218-01-9		B2	7.3e-03	2.8e+01	4
m-cresol	95-48-7	5.0e-02	C		1.0e+03	1a
o,-Cresol	108-39-4	5.0e-02	C		1.0e+03	1a
p-Cresol	106-44-5	5.0e-03			3.4e+02	1
Dibenzo(a,h)anthracene	53-70-3		B2	7.3e+00	2.8e-02	4
Di-n-butyl phthalate	84-74-2	1.0e-01	D		1.0e+03	1a
Di-n-octyl phthalate	117-84-0	2.0e-02			1.4e+03	2
3,3'-Dichlorobenzidine	91-94-1		B2	4.5e-01	4.5e-01	1
2,4-Dichlorophenol	120-83-2	3.0e-03			2.0e+02	1
Diethyl phthalate	84-66-2	8.0e-01	D		1.0e+03	1a
Dimethyl phthalate	131-11-3	1.0e+01	D		1.0e+03	2a
2,4-Dinitrotoluene	121-14-2	2.0e-03			1.4e+02	1
Fluoranthene	206-44-0	4.0e-02	D		1.0e+03	1a
Fluorene	86-73-7	4.0e-02	D		1.0e+03	1a
Hexachloroethane	67-72-1	1.0e-03	C	1.4e-02	1.5e+01	1
Hexachlorobenzene	118-74-1	8.0e-04	B2	1.6e+00	1.3e-01	1g
Hexachlorobutadiene	87-68-3	2.0e-04	C	7.8e-02	2.6e+00	2
Hexachlorocyclopentadiene	77-47-4	7.0e-03	D		4.7e+02	1
Indeno(1,2,3-cd)pyrene	193-39-5		B2	7.3e-01	2.8e-01	4
Isophorone	78-59-1	2.0e-01	C	9.5e-04	2.1e+02	1
Naphthalene	91-20-3	4.0e-03	D		2.7e+02	3
Nitrobenzene	98-95-3	5.0e-04	D		3.4e+01	1
N-Nitrosodi-N-propylamine	621-64-7		B2	7.0e+00	2.9e-02	1
N-Nitrosodiphenylamine	86-30-6		B2	4.9e-03	4.2e+01	1
Pentachlorophenol	87-86-5	3.0e-02	B2	1.2e-01	1.7e+00	1
Phenanthrene	85-01-8	3.0e-02	D		1.0e+03	1a,d
Phenol	108-95-2	6.0e-01	D		1.0e+03	1a
Pyrene	129-00-0	3.0e-02	D		1.0e+03	1a
Pyridine	110-86-1	1.0e-03			6.8e+01	1
1,2,4-Trichlorobenzene	120-82-1	1.0e-02	D		6.8e+02	1
2,4,5-Trichlorophenol	95-95-4	1.0e-01			1.0e+03	1a
2,4,6-Trichlorophenol	88-06-2		B2	1.1e-02	1.9e+01	1
Inorganic Compounds						
Aluminum	7429-90-5	1.0e+00	D		6.8e+04	4
Antimony	7440-36-0	4.0e-04			2.7e+01	1
Arsenic (total)	7440-38-2	3.0e-04	A	1.5e+00	1.4e-01	1
Asbestos in mfl	1332-21-4		A			1
Barium	7440-39-3	7.0e-02			4.7e+03	1
Beryllium	7440-41-7	5.0e-03	B2	4.3e+00	4.7e-02	1
Cadmium	7440-43-9	5.0e-04	B1		3.4e+01	1

Chemical	CAS #	RfD	Carcinogen Class	CSF	STC (mg/kg)	Refs & Notes
Chromium (total)	7440-47-3	5.0e-03			3.4e+02	2k
Chromium, trivalent	16065-83-1	1.0e+00			3.9e+03	1a
Chromium, hexavalent	18540-29-9	5.0e-03	A		1.0e+02	1
Copper	7440-50-8	4.0e-02	D		2.7e+03	4
Cyanide	57-12-5	2.0e-02	D		1.4e+03	1
Lead	7439-92-1		B2			1f
Mercury (inorganic)	7439-97-6	3.0e-04	D		2.0e+01	2g
Nitrate as N	14797-55-8	1.6e+00			1.1e+05	1
Nitrite as N	14797-65-0	1.0e-01			6.8e+03	1
Nickel (soluble salts)	7440-02-0	2.0e-02	D		1.4e+03	1
Selenium	7782-49-2	5.0e-03	D		3.4e+02	1
Silver	7440-22-4	5.0e-03	D		3.4e+02	1
Thallium	7446-18-6	8.0e-05	D		5.4e+00	1h
Vanadium	7440-62-2	7.0e-03			4.7e+02	2
Zinc	7440-66-6	3.0e-01	D		2.0e+04	1
Pesticides and PCBs						
Alachlor	15972-60-8	1.0e-02	B2	8.0e-02	2.6e+00	12
Aldicarb	116-06-3	1.0e-03			1.4e+01	1a
Atrazine	1912-24-9	3.5e-02	C	2.2e-01	9.3e-01	2
Dieldrin	60-57-1	5.0e-05	B2	1.6e+01	1.3e-02	1g
DDT	50-29-3	5.0e-04	B2	3.4e-01	6.0e-01	1g
DDE	72-55-9		B2	3.4e-01	6.0e-01	1g
DDD	72-54-8		B2	2.4e-01	8.5e-01	1g
Endrin	72-20-8	3.0e-04	D		2.0e+01	1g
2-4 D	94-75-7	1.0e-02			6.8e+02	1
Heptachlor epoxide	1024-57-3	1.3e-05	B2	9.1e+00	2.2e-02	1g
Heptachlor	76-44-8	5.0e-04	B2	4.5e+00	4.5e-02	1g
Lindane	58-89-9	3.0e-04			2.0e+01	1
Methoxychlor	72-43-5	5.0e-03	D		3.4e+02	1g
Toxaphene	8001-35-2		B2	1.1e+00	1.9e-01	1g
PCBs	1366-36-3	2.0e-05	B2	2.0e+00	1.0e-01	4g,i
2,3,7,8-TCDD	1746-01-6		B2	1.6e+05	1.3e-06	4g,j

KEY:
CAS# = Chemical Abstract Service Number
CSF = Oral Cancer Slope Factor
RfD = Oral Reference Dose

DEFINITIONS:
USEPA Cancer Class: former carcinogen classification system used by USEPA; although recently modified,

most chemicals haven't yet been reclassified. Classes defined as follows:
GROUP A: Chemicals determined to have STRONG evidence of carcinogenicity in HUMANS.
GROUP B1: Chemicals determined to have STRONG evidence of carcinogenicity in ANIMALS, but which have LIMITED evidence of carcinogenicity in HUMANS.
GROUP B2: Chemicals determined to have STRONG evidence of carcinogenicity in ANIMALS, but which have WEAK evidence of carcinogenicity in ANIMALS.
GROUP C: Chemicals determined to have LIMITED evidence of carcinogenicity in ANIMALS, but which have

NO evidence of carcinogenicity in HUMANS.
GROUP D: Chemicals which have INADEQUATE DATA to determine the carcinogenicity.
GROUP E: Chemicals determined to have evidence of non-carcinogenicity.

Table 1. Screening Target Concentrations (STCs) for Waste Reuse

CSF: Chemical-specific cancer slope factor, as derived by USEPA, is an estimate of the cancer risk due to continuous daily exposure over a 70 year lifetime.
RfD: Chemical-specific reference dose representing the daily exposure which humans, including sensitive subpopulations may receive chronically without a significant risk of adverse effect.

REFERENCES:
US EPA, 1989. Exposure Factors Handbook. Office of Research and Environmental Assessment.
1 - US EPA 1997. Integrated Risk Information System (IRIS). On-line Database.
2 - US EPA 1995. Health Effects Assessment Summary Tables (HEAST). Annual FY 1995.
3 - USEPA/Office of Drinking Water Health Advisory Documents.
4 - Region III Risk-Based Concentration Tables, March, 1997 update

NOTES:
Blank = no data was available, unless otherwise noted.
a - STC taken from CT Remed. Std. Regs. since risk-based value is above ceiling level or other guidance.
b - TCE cancer slope factor listed on Region III table, but was withdrawn from IRIS.
c - No toxicity value available; acenaphthene RfD used as surrogate based on structural similarity.
d - No toxicity value available; pyrene RfD used as surrogate based on structural similarity.
e - Carcinogen classification based upon inhalation dose route.
f - Health risks from lead in soil or waste products need to be evaluated via uptake/biokinetic modeling.
g - Bioaccumulative chemical for which multi-pathway assessment needed regardless of comparison against STC.
h - Assumes thallium (I) sulfate.
i - PCB toxicity values based upon highly chlorinated Aroclors;
j - TCDD RfD will need to be derived for non-cancer multi-pathway assessment.
k - Chromium (total) STC based upon assumption of 1/3rd total chromium as CrVI.

Waste Reuse Screening Groundwater Target Concentrations
(SGTCs Based upon Residential Ingestion of Groundwater)

Equations:

Carcinogens:
RISK = CSF x DOSE

DOSE = GWTC x EXPOSURE

GWTC = (RISK x BW x AT) / (CSF x IR x EF x ED x CF)

Non-carcinogens:
HI = DOSE / RfD

DOSE = GWPC x EXPOSURE

GWTC = (RfD x HI x BW x AT x SA) / (IR x EF x ED x CF)

Character	Description	Units	Value
SGTC -	Screening Groundwater Target Conc.	ug/l	calc.
IR -	Ingestion Rate	l/d	2
EF -	Exposure Frequency	days/year	365
ED -	Exposure Duration	years	70
CF -	Conversion Factor	mg/ug	1.00E-03
CSF -	Cancer Slope Factor (oral)	(mg/kg-day)-1	chem-spec.
RfD -	Reference Dose (oral)	mg/kg-day	chem-spec.
BW -	Body Weight	kg	70
AT -	Averaging Time	days	25550
RISK -	Target Cancer Risk Level	unitless	5.00E-07
HI -	Hazard Index	unitless	1
SA -	Source Allocation	unitless	0.2
Source for exposure parameter values: USEPA Exposure Factors Handbook, 1989			

Table 2. Screening Groundwater Target Concentrations (SGTCs) for Waste Reuse

Chemical	CAS #	RfD	Carcinogen Class	CSF	SGTC (ug/l)	Refs & Notes
Volatile Organic Compounds						
Acetone	67-64-1	1.0E-01	D		7.0E+02	1
Acrylonitrile	107-13-1		B1	5.4E-01	3.2E-02	1
Benzene	71-43-2		A	2.9E-02	6.0E-01	1
Bromoform	75-25-2	2.0E-02	B2	7.9E-03	2.2E-00	1
2-Butanone (MEK)	78-93-3	6.0E-01	D		4.0E+02	1a
Carbon tetrachloride	56-23-5	7.0E-04	B2	1.3E-01	1.3E-01	1
Chlorobenzene	108-90-7	2.0E-02	D		1.0E+02	1a
Chloroform	67-66-3	1.0E-02	B2	6.1E-03	2.9E-00	1
Dibromochloromethane	124-48-1	2.0E-02	C	8.4E-02	2.1E-01	1
1,2-Dichlorobenzene	95-50-1	9.0E-02	D		6.0E+02	1a
1,3-Dichlorobenzene	541-73-1	9.0E-02	D		6.0E+02	1a
1,4-Dichlorobenzene	106-46-7	1.0E-01	B2/C	2.4E-02	7.3E-01	2,3
1,1-Dichloroethane	75-34-3	1.0E-01	C		7.0E+01	2a
1,2-Dichloroethane	107-06-2		B2	9.1E-02	1.9E-01	1
1,1-Dichloroethylene	75-35-4	9.0E-03	C	6.0E-01	2.9E-02	1
cis-1,2-Dichloroethylene	156-59-2	1.0E-02	D		7.0E+01	1,2
trans-1,2-Dichloroethylene	156-60-5	2.0E-02	D		1.0E+02	1,2a
1,2-Dichloropropane	78-87-5	3.7E-04	B2	6.8E-02	2.6E-01	2
1,3-Dichloropropene	542-75-6	3.0E-04	B2	1.8E-01	9.7E-02	1,2
Ethylbenzene	100-41-4	1.0E-01	D		7.0E+02	1
Ethylene dibromide (EDB)	106-93-4		B2	8.5E+01	2.1E-04	1
Methyl-t-butyl-ether (MTBE)	1634-04-4	5.0E-03			3.5E+01	4
Methyl isobutyl ketone	108-10-1	8.0E-02			3.5E+02	2a
Methylene chloride	75-09-2	6.0E-02	B2	7.5E-03	2.3E-00	1
Styrene	100-42-5	2.0E-01			1.0E+02	1a
1,1,1,2-Tetrachloroethane	630-20-6	3.0E-02	C	2.6E-02	6.7E-01	1
1,1,2,2-Tetrachloroethane	79-34-5		C	2.0E-01	8.8E-02	1
Tetrachloroethylene	127-18-4	1.0E-02	C-B2	5.2E-02	3.4E-01	1,4
Toluene	108-88-3	2.0E-01	D		1.0E+03	2a
1,1,1-Trichloroethane	71-55-6	3.5E-02	D		2.0E+02	4a
1,1,2-Trichloroethane	79-00-5	4.0E-03	C	5.7E-02	3.1E-01	1
Trichloroethylene	79-01-6	6.0E-03	B2/C	1.1E-02	1.6E-00	4b
Vinyl chloride	75-01-4		A	1.9E-00	9.2E-03	2
Xylenes	1330-20-7	2.0E-00	D		5.3E+02	1a
Semivolatile Organic Compounds						
Acenaphthene	83-32-9	6.0E-02	D		4.2E+02	1
Acenaphthylene	208-96-8	6.0E-02	D		4.2E+02	1c
Anthracene	120-12-7	3.0E-01	D		2.0E+03	1
Benzidine	92-87-5	3.0E-03	A	2.3E+02	7.6E-05	1
Benz(a)anthracene	56-55-3		B2	7.3E-01	2.4E-02	4
Benzo(b)fluoranthene	205-99-2		B2	7.3E-01	2.4E-02	4
Benzo(k)fluoranthene	207-08-9		B2	7.3E-02	2.4E-01	4
Benzo(a)pyrene	50-32-8		B2	7.3E-00	2.4E-03	1
Bis(2-chloroethyl)ether	111-44-4		B2	1.1E-00	1.6E-02	1
Bis(2-chloroisopropyl)ether	39638-32-9	4.0E-02	C	7.0E-02	2.5E-01	1,2
Bis (2-ethyl hexyl)phthalate	117-81-7	2.0E-02	B2	1.4E-02	1.3E-00	1

Chemical	CAS #	RfD	Carcinogen Class	CSF	SGTC (ug/l)	Refs & Notes
Butyl benzyl phthalate	85-68-7	2.0E-01	C		1.0E+03	1a
2-Chloronaphthalene	91-58-7	8.0E-02			5.6E+02	1
2-Chlorophenol	95-57-8	5.0E-03			3.5E+01	1
Chyrsene	218-01-9		B2	7.3E-03	2.4E-00	4
m-cresol	95-48-7	5.0E-02	C		3.5E+02	1
o,-Cresol	108-39-4	5.0E-02	C		3.5E+02	1
p-Cresol	106-44-5	5.0E-03			3.5E+01	1
Dibenzo(a,h)anthracene	53-70-3		B2	7.3E-00	2.4E-03	4
Di-n-butyl phthalate	84-74-2	1.0E-01	D		7.0E+02	1
Di-n-octyl phthalate	117-84-0	2.0E-02			1.0E+02	2a
3,3'-Dichlorobenzidine	91-94-1		B2	4.5E-01	3.9E-02	1
2,4-Dichlorophenol	120-83-2	3.0E-03			2.1E+01	1
Diethyl phthalate	84-66-2	8.0E-01	D		1.0E+03	1a
Dimethyl phthalate	131-11-3	1.0E+01	D		1.0E+03	2a
2,4-Dinitrotoluene	121-14-2	2.0E-03			1.4E+01	1
Fluoranthene	206-44-0	4.0E-02	D		2.8E+02	1
Fluorene	86-73-7	4.0E-02	D		2.8E+02	1
Hexachloroethane	67-72-1	1.0E-03	C	1.4E-02	1.3E-00	1
Hexachlorobenzene	118-74-1	8.0E-04	B2	1.6E-00	1.1E-02	1g
Hexachlorobutadiene	87-68-3	2.0E-04	C	7.8E-02	2.2E-01	2
Hexachlorocyclopentadiene	77-47-4	7.0E-03	D		4.9E+01	1
Indeno(1,2,3-cd)pyrene	193-39-5		B2	7.3E-01	2.4E-02	4
Isophorone	78-59-1	2.0E-01	C	9.5E-04	1.8E+01	1
Naphthalene	91-20-3	4.0E-03	D		2.8E+01	3
Nitrobenzene	98-95-3	5.0E-04	D		3.5E-00	1
N-Nitrosodi-N-propylamine	621-64-7		B2	7.0E-00	2.5E-03	1
N-Nitrosodiphenylamine	86-30-6		B2	4.9E-03	3.6E-00	1
Pentachlorophenol	87-86-5	3.0E-02	B2	1.2E-01	1.5E-01	1
Phenanthrene	85-01-8	3.0E-02	D		2.1E+02	1d
Phenol	108-95-2	6.0E-01	D		4.0E+03	1a
Pyrene	129-00-0	3.0E-02	D		2.1E+02	1
Pyridine	110-86-1	1.0E-03			7.0E-00	1
1,2,4-Trichlorobenzene	120-82-1	1.0E-02	D		7.0E+01	1
2,4,5-Trichlorophenol	95-95-4	1.0E-01			7.0E+02	1
2,4,6-Trichlorophenol	88-06-2		B2	1.1E-02	1.6E-00	1
Inorganic Compounds						
Aluminum	7429-90-5	1.0E-00	D		7.0E+03	4
Antimony	7440-36-0	4.0E-04			2.8E-00	1
Arsenic (total)	7440-38-2	3.0E-04	A	1.5E-00	1.2E-02	1
Asbestos in mfl	1332-21-4		A			1e
Barium	7440-39-3	7.0E-02			4.9E+02	1
Beryllium	7440-41-7	5.0E-03	B2	4.3E-00	4.1E-03	1
Cadmium	7440-43-9	5.0E-04	B1		3.5E-00	1e
Chromium (total)	7440-47-3	5.0E-03			3.5E+01	2
Chromium, trivalent	16065-83-1	1.0E-00			7.0E+03	1
Chromium, hexavalent	18540-29-9	5.0E-03	A		3.5E+01	1e
Copper	7440-50-8	4.0E-02	D		2.8E+02	4
Cyanide	57-12-5	2.0E-02	D		1.4E+02	1
Lead	7439-92-1		B2			1f

Chemical	CAS #	RfD	Carcinogen Class	CSF	SGTC (ug/l)	Refs & Notes
Mercury (inorganic)	7439-97-6	3.0E-04	D		2.1E-00	2g
Nitrate as N	14797-55-8	1.6E-00			1.1E+04	1
Nitrite as N	14797-65-0	1.0E-01			7.0E+02	1
Nickel (soluble salts)	7440-02-0	2.0E-02	D		1.0E+02	1a
Selenium	7782-49-2	5.0E-03	D		3.5E+01	1
Silver	7440-22-4	5.0E-03	D		3.5E+01	1
Thallium	7446-18-6	8.0E-05	D		5.6E-01	1h
Vanadium	7440-62-2	7.0E-03			4.9E+01	2
Zinc	7440-66-6	3.0E-01	D		2.1E+03	1
Pesticides and PCBs						
Alachlor	15972-60-8	1.0E-02	B2	8.0E-02	2.2E-01	1,2
Aldicarb	116-06-3	1.0E-03			3.0E-00	1a
Atrazine	1912-24-9	3.5E-02	C	2.2E-01	8.0E-02	2
Dieldrin	60-57-1	5.0E-05	B2	1.6E+01	1.1E-03	1g
DDT	50-29-3	5.0E-04	B2	3.4E-01	5.1E-02	1g
DDE	72-55-9		B2	3.4E-01	5.1E-02	1g
DDD	72-54-8		B2	2.4E-01	7.3E-02	1g
Endrin	72-20-8	3.0E-04	D		2.1E-00	1g
2-4 D	94-75-7	1.0E-02			7.0E+01	1
Heptachlor epoxide	1024-57-3	1.3E-05	B2	9.1E-00	1.9E-03	1g
Heptachlor	76-44-8	5.0E-04	B2	4.5E-00	3.9E-03	1g
Lindane	58-89-9	3.0E-04			2.0E-01	1a
Methoxychlor	72-43-5	5.0E-03	D		3.5E+01	1g
Toxaphene	8001-35-2		B2	1.1E-00	1.6E-02	1g
PCBs	1366-36-3	2.0E-05	B2	2.0E-00	8.8E-03	4g,i
2,3,7,8-TCDD	1746-01-6		B2	1.6E+05	1.1E-07	4g,j

KEY:
CAS# = Chemical Abstract Service Number
CSF = Oral Cancer Slope Factor
RfD = Oral Reference Dose

DEFINITIONS:
USEPA Cancer Class: former carcinogen classification system used by USEPA; although recently modified,
most chemicals haven't yet been reclassified. Classes defined as follows:

GROUP A: Chemicals determined to have STRONG evidence of carcinogenicity in HUMANS.
GROUP B1: Chemicals determined to have STRONG evidence of carcinogenicity in ANIMALS, but which have
LIMITED evidence of carcinogenicity in HUMANS.
GROUP B2: Chemicals determined to have STRONG evidence of carcinogenicity in ANIMALS, but which have
WEAK evidence of carcinogenicity in ANIMALS.
GROUP C: Chemicals determined to have LIMITED evidence of carcinogenicity in ANIMALS, but which have
NO evidence of carcinogenicity in HUMANS.
GROUP D: Chemicals which have INADEQUATE DATA to determine the carcinogenicity.
GROUP E: Chemicals determined to have evidence of non-carcinogenicity.

CSF: Chemical-specific cancer slope factor, as derived by USEPA, is an estimate of the cancer risk due to Continuous daily exposure over a 70 year lifetime.
RfD: Chemical-specific reference dose representing the daily exposure which humans, including sensitive subpopulations may receive chronically without a significant risk of adverse effect.

Table 2. Screening Groundwater Target Concentrations (SGTCs) for Waste Reuse

REFERENCES:

US EPA, 1989. Exposure Factors Handbook. Office of Research and Environmental Assessment.

1 - US EPA 1997. Integrated Risk Information System (IRIS). On-line Database.

2 - US EPA 1995. Health Effects Assessment Summary Tables (HEAST). Annual FY 1995.

3 - USEPA/Office of Drinking Water Health Advisory Documents.

4- Region III Risk-Based Concentration Tables, March, 1997 update

NOTES:

Blank = no data was available, unless otherwise noted.

b - TCE cancer slope factor listed on Region III table, but was withdrawn from IRIS.

c - No toxicity value available; acenaphthene RfD used as surrogate based on structural similarity.

d - No toxicity value available; pyrene RfD used as surrogate based on structural similarity.

e - Carcinogen classification based upon inhalation dose route.

f - Health risks from lead in soil or waste products need to be evaluated via uptake/biokinetic modeling.

h - Assumes thallium (I) sulfate.

i - PCB toxicity values based upon highly chlorinated Aroclors;

j - TCDD RfD will need to be derived for non-cancer multi-pathway assessment.

Ecological Risk Assessment (ERA) Guidance for Beneficial Use

Waste reutilization in a beneficial use context may cause exposure to a variety of ecological receptors to toxic constituents originally present in the waste. These constituents may be released during processing of the waste, application of the waste-containing product, or due to environmental releases from weathering and various transport processes. Such potential exposure pathways need to be evaluated to ensure that waste materials are not used in a manner which would increase ecological risks to an unacceptable degree.

During the course of evaluating a proposal for the beneficial use of a solid waste pursuant to Section 22a-209f of the Connecticut General Statutes, the Department may determine that an ERA is necessary to address potential risks to the environment. This guidance describes a process for performing this type of an assessment which consists of a tiered approach to evaluating the potential impact on the environment associated with various beneficial use scenarios. Tier 1 consists of a baseline screening level risk assessment in which a solid waste or associated product is compared against a variety of Ecological Benchmarks. Should this comparison indicate a potential for environmental harm, a second, more detailed ERA (Tier 2) will need to be performed.

The results of these assessments will be used by the Department to determine whether the proposed activities will negatively impact the environment. It will identify constituents which are below levels of concern and those for which additional information may be needed. Primary inputs to the ERA process are characterization of the solid waste and/or associated product, including its processing and handling, and chemical constituents. The key input for the Tier 1 assessment is the 95% upper confidence limit (UCL) on the mean concentrations in the waste, beneficial use product, or associated leachates (as determined by TCLP or SPLP procedures). The 95% UCL concentrations are to be based upon sufficient and representative sampling so as to comply with CTDEP requirements for characterization of the waste stream or beneficial use product. The Tier 2 evaluation begins with these 95% UCL concentrations, but can then incorporate appropriate environmental fate and transport modeling predictions to derive exposure point concentrations (EPCs) resulting from the various proposed uses of the material. For both tiers of the ERA, DEP has streamlined the process by specifying certain details in advance.

The following steps outline the phased approach recommended for ERA for beneficial use:

1. Description of Scenarios Involving the Potential for Exposure To Ecological Receptors:
The processing, application/use, and eventual environmental fate of the waste should be described from the context of the potential for releases of toxic constituents into the environment. All relevant fate and transport processes should be considered. Exposure pathways involving ecological receptors from the ecosystems and trophic levels described in Tables 1 thru 4 should be identified with those pathways representing the greatest potential for exposure discussed in terms of how constituents reach receptors, which media would be affected (i.e., would receptors contact affected air, water, soil, sediment, food chain exposures, or waste product directly), and which exposure mechanisms would be involved (ingestion, dermal uptake, inhalation, etc.). This qualitative description will help frame the exposure and risk analyses which follow.

2. Comparison of Constituent Concentrations in the Waste or Beneficial Use Product to Ecological Benchmarks - Tier 1 Approach:

Tier 1, Baseline Screening Level ERA, is a simplified procedure which assumes that key receptors come in direct contact with either the solid waste, the beneficial use product, or the potential leachates that could arise as measured by TCLP or SPLP procedures. DEP has simplified the exposure assessment, toxicological evaluations and risk determinations for Tier 1 ERA by incorporating standard assumptions into a series of equations and evaluations. Exposure modeling involving fate and transport equations is not used for Tier 1 evaluations.

Tier 1 toxicological evaluations have been simplified through the development of Screening Level Ecological Benchmarks. These benchmarks represent media-specific ambient environmental concentrations which are not likely to pose unacceptable risks to ecological receptors. Benchmarks are provided in Tables 6-10 for surface water, sediment, shallow ground water and soil. These benchmark values may be updated by the Department as necessary. Additional benchmarks should be derived for any constituent, not included in the attached tables, which could potentially be present in the solid waste. Consult the references cited in Table 5 for a description of the derivation of these benchmark values.

To evaluate ecological risk, hazard quotients need to be calculated for each constituent by evaluating the ratio of the constituent in either the solid waste, beneficial use produce, or its leachate to the appropriate environmental benchmark. The 95% upper confidence limit of the mean for each constituent potentially present in the solid waste/product should be used with the benchmarks for soil and sediment while the 95% UCL values resulting from the leaching evaluations should be compared with the surface water and groundwater benchmarks . Hazard quotients less than 1 represent a reduced potential for environmental harm. If any constituent concentrations yield hazard quotients equal to or greater than 1, a more detailed and/or site-specific predictive ERA (Tier 2) would be needed to determine if the overall scenario is associated with elevated ecological risks.

As described below, a Tier 1 screening level approach is not recommended for compounds which are persistent in the environment or exhibit a strong tendency to bioaccumulate through the food chain.

A modified Tier 1 screening level approach is needed for compounds for which analytical detection limits are greater than the Ecological Benchmarks. If such compounds may be potentially present in solid waste, the beneficial use product, or the associated leachate below these detection limits, these compounds should still be addressed in Tier 1. Possible approaches are calculating the constituent concentration using dilution factors to go from a medium where the constituent was detected (e.g., unprocessed waste) to the product, or by applying one-half the detection limit.

3. Determination of whether additional analysis (Tier 2) is necessary:

<u>A. Exceedance of Ecological Benchmarks:</u>
The Tier 1 approach may be a conservative frame of reference in that product constituent concentrations are compared directly against the benchmark concentrations without factoring in dilution that might occur through transport processes. If benchmarks are exceeded, the applicant has the option of deriving exposure point concentrations (EPCs) to which ecological receptors may be exposed by performing realistic but conservative fate and transport modeling (see Step 4). These modeled EPCs would then be used as the basis for evaluating the ecological risks in a

comprehensive Tier 2 analysis.

B. Presence of Bioaccumulative Compounds:
A variety of chemicals have been included in Table 6 which may be persistent or accumulate in organisms or magnify thru the food chain. Examples of such compounds include polychlorinated biphenyls (PCBs), dioxins and furans, mercury, certain pesticides, polycyclic aromatic hydrocarbons and, in general, constituents with a log octanol-water partition coefficient (Kow) greater than or equal to 3.5. A screening level approach is not appropriate for evaluating these chemicals, and the screening level values provided in the tables are for informational purposes only. A multipathway assessment conducted using Tier 2 procedures is required for these constituents.

4. Tier 2 Approach: Predictive ERA

Tier 2 should contain all ERA components as described in EPA guidance documents (Framework for Ecological Risk Assessment, EPA, 1992; Proposed Guidelines for Ecological Risk Assessment , EPA, 1996). For Tier 2, distribution of waste or beneficial use product constituents into and transfer of these constituents within the various abiotic media (surface water, groundwater, sediment, soil) may be modeled. Models used to simulate constituent release and transport in the environment and uptake/bioaccumulation into food webs should conform with the guidance outlined for human health risk assessment multi-pathway risk assessment (Attachment A, Step 4). Additional features of the exposure assessment for Tier 2 ERA are as follows:

Include all relevant release mechanisms that could occur during the processing, storage, application, repair, or weathering of the beneficial use product; include an assessment of extreme scenarios (e.g., road washout into a stream bed for a use product going into road subsurface); exclusion of any potential release scenarios from the quantitative analysis should be explained and justified.

Calculate EPCs in all affected media for all transported chemicals; NOTE: even though only some constituents may have triggered a Tier 2 analysis due to their exceedance of Ecological Benchmarks in Tier 1 or because they are highly bioaccumulative, the Tier 2 ERA should include exposure and risk analysis for all constituents. This will allow the quantitation of aggregate risk across constituents as appropriate (see below). Calculations for abiotic media should include soil (from aerial deposition, runoff, erosion, etc.), groundwater (from leaching), and surface water (from aerial deposition, runoff, erosion, etc.) and sediment (from deposition, runoff, erosion, sedimentation, etc);

Model uptake into food web from affected soil, water, sediment; include uptake into edible plants (primary producers), primary consumers, intermediate consumers, and dominant carnivores for each ecosystem analyzed as appropriate (see Tables 1-4). The applicant should consider site-specific or region-specific threatened and endangered species for inclusion in the analysis (contact DEP, Natural Diversity Database).

Similar to Tier 1 evaluations, evaluation of risks are made by calculating hazard quotients using the types of Ecological Benchmarks described under Tier 1. However, in Tier 2, the input (abiotic) concentrations can be those derived through environmental modeling of release and transport scenarios specific to the intended uses. Further, the Ecological Benchmarks are modified for the specific wildlife receptors being analyzed in Tier 2 to reflect their rate of exposure to constituents in environmental media per body weight. These receptor-specific Ecological Benchmarks for wildlife are derived as described by Sample et al. (1996), using EPA guidance to estimate the degree of exposure possible for each receptor (Wildlife Exposure Factors Handbook, Vol.I,EPA/600/R-93/187A). This type of analysis is needed for wildlife at each of the trophic levels and each of the ecosystems that pertain to the use scenario (see Tables 1-4). While DEP has not provided Ecological Benchmarks for wildlife species not included in Sample et al., 1996, these benchmarks can be readily calculated as part of Tier 2 evaluations using the procedures described in that reference. Additionally, benchmarks for amphibians and reptiles have not been provided although these organisms have been included as appropriate receptors. A literature search should be conducted to determine the potential for solid waste constituents to affect these receptors and develop appropriate benchmark values.

Tier 2 evaluations should involve aggregate risk calculations to include multiple exposures of receptors to solid waste constituents across the various abiotic media and food chain pathways identified. Such evaluations should be conducted by adding hazard quotients for each chemical or groups of chemicals with similar toxic effects or target organs across the various media. Aggregate risk should also be summed across the different release/transport mechanisms that could impact a given area (e.g., erosion/runoff from storage piles plus aerial deposition from processing facility plus erosion/runoff from product once applied).

If modeling the transport, distribution, and/or bioaccumulation of constituents will be part of the Tier 2 evaluation, the applicant is strongly encouraged to submit a protocol detailing the proposed modeling methodologies. For more information on the protocols which should be used for Tier 2 Predictive ERA, please refer to references identified in Table 5 and the bibliography below.

5. ERA Submittal:

The applicant should submit any analyses performed to fulfill the steps outlined above. Thus, even in cases where a Tier 2 ERA is necessary (Step 4), the analyses that led to its conduct (Steps 1 thru 3) should also be presented. If elevated ecological risks are found (hazard quotients greater than 1), the applicant has the option to describe any use restrictions or control measures that would reduce risks; these risk reductions should be described quantitatively to the extent possible.

Table 1: Salt Marsh Food Web

Trophic Level		Organisms	Benchmark
Primary Producers:		Vascular Plants	Phytotoxicity: Soil & Groundwater
		Phytoplankton	Aquatic Life
<u>Primary Consumers</u>			
	Herbivorous Mammals		Wildlife
	Benthic Invertebrates	Oligochaetes, Polychaetes Bivalves, Gastropods, Decapods	Sediment
		Planktivorous Fish	Aquatic Life
	Herbivorous Waterfowl	Canada Goose	Wildlife
<u>Intermediate Consumers</u>			
	Omnivorous Mammals	Muskrat, Raccoon	Wildlife
	Omnivorous Birds	Marsh Wren	Wildlife
	Omnivorous Waterfowl	Mallard, Lesser Scaup	Wildlife
	Carnivorous Shorebirds	Spotted Sandpiper	Wildlife
	Omnivorous Fish		Aquatic Life
<u>Dominant Carnivores</u>			
	Carnivorous Mammals	Mink, River Otter	Wildlife
	Raptors & Large Carnivorous Birds	American Kestrel	Wildlife
	Piscivorous/Carnivorous Sea Birds	Great Blue Heron, Belted Kingfisher Osprey	Wildlife
	Large Carnivorous Reptiles		
	Large Carnivorous Fish		Aquatic Life

Table 2: Brackish/Intermediate Marsh Food Web

Trophic Level	Organisms	Benchmark
Primary Producers:	Vascular Plants	Phytotoxicity Soil & Groundwater
	Phytoplankton	
Primary Consumers		
Herbivorous Mammals	Whitetail deer	Wildlife
Benthic Invertebrates	Oligochaetes,Bivalves Insects, Snails	Aquatic Life
Planktivorous Fish		Aquatic Life
Herbivorous Waterfowl	Canada Goose	Wildlife
Intermediate Consumers		
Omnivorous Mammals	Muskrat, Raccoon	Wildlife
Omnivorous Amphibians And Reptiles	Snapping Turtle	
Omnivorous Birds	Marsh Wren	Wildlife
Omnivorous Waterfowl	Mallard, Lesser Scaup	Wildlife
Carnivorous Shorebirds	Spotted Sandpiper	Wildlife
Omnivorous Fish		Aquatic Life
Dominant Carnivores		
Carnivorous Mammals	Mink, River Otter	Wildlife
Raptors & Large Carnivorous Birds	American Kestrel, Bald Eagle	Wildlife
Piscivorous/Carnivorous Sea Birds	Great Blue Heron, Belted Kingfisher, Osprey, Herring Gull	Wildlife
Large Carnivorous Reptiles		
Large Carnivorous Fish		Aquatic Life

Table 3: Freshwater Food Web

Trophic Level		Organisms	Benchmark
Primary Producers:		Vascular Plants	Phytotoxicity: Soil & Groundwater
		Phytoplankton	Aquatic Life
Primary Consumers			
	Herbivorous Mammals	White-tailed deer	Wildlife
	Aquatic Invertebrates	Oligochaetes,Bivalves, Insects,Snails, Water Column Invertebrates	Aquatic Life
	Planktivorous Fish		Aquatic Life
	Herbivorous Waterfowl	Canada Goose	Wildlife
Intermediate Consumers			
	Omnivorous Mammals	Muskrat, Short Tail Shrew,Wildlife Meadow Vole, Raccoon	Wildlife
	Omnivorous Amphibians And Reptiles	Painted Turtle, Snapping Turtle, Eastern Newt	
	Omnivorous Birds	Marsh Wren	Wildlife
	Omnivorous Waterfowl	Mallard	Wildlife
	Carnivorous Shorebirds	Spotted Sandpiper	Wildlife
	Omnivorous Fish		Aquatic Life
Dominant Carnivores			
	Carnivorous Mammals	Mink, River Otter	Wildlife
	Raptors & Large Carnivorous Birds	American Kestrel, Bald Eagle	Wildlife
	Piscivorous, Carnivorous Sea Birds	Great Blue Heron, Belted Kingfisher, Herring Gull, Osprey	Wildlife
	Large Carnivorous Reptiles	Snapping Turtle, Bull Frog, Northern Water Snake	
	Large Carnivorous Fish		Aquatic Life

Table 4: Terrestrial Food Web

Trophic Level	Organisms	Benchmark
Primary Producers:	Vascular Plants	Phytotoxicity: Soil & Groundwater
	Trees	
Primary Consumers		
Herbivorous Mammals	Cotton Tail Rabbit	Wildlife
Terrestrial Invertebrates	Insects, Arachnids, Gastropods, Oligochaetes, Arthropods	Soil & Litter Invertebrates
Intermediate Consumers		
Omnivorous Mammals	Short-Tailed Shrew, Meadow Vole, Raccoon, White footed Mouse	Wildlife
Omnivorous Amphibians And Reptiles	Eastern Box Turtle, Eastern Newt	
Omnivorous Birds	American Woodcock, American Robin, Northern Bobwhite	Wildlife
Dominant Carnivores		
Carnivorous Mammals	Red Fox	Wildlife
Raptors & Large Carnivorous Birds	Red-Tailed Hawk, Bald Eagle, American Kestrel	Wildlife
Large Carnivorous Reptiles	Racer	

Table 5: Benchmark Derivation

Abiotic Media	Organisms	Benchmark(*)	Reference
Surface Water	Aquatic Life	Connecticut Water Quality Criteria	CT DEP 1997
		Federal Water Quality Criteria	EPA 1987
		Great Lakes: Tier 2 Benchmarks	EPA 1995, Suter and Tsao,1996
		Wildlife Drinking Water	Sample *et. Al.*, 1996
		Piscivorous Organisms	Sample *et. Al.*, 1996
Groundwater	Phytotoxicity (Plants)	Solution Based Benchmark	Will and Suter, 1995
Sediment	Benthic Invertebrates:		
		for organic chemicals:	
		Sediment Quality Criteria	EPA, 1993 a-e
		Equilibrium Partitioning Based Benchmarks	EPA 1993 f
		Effects Range - Low	Long and Morgan,1991
		TEL	MacDonald
		Lowest Effects Level	Persuad
		for inorganic chemicals:	
		Effects Range - Low	Long and Morgan
		TEL	MacDonald
		Lowest Effects Level	Persuad
Soil	Soil & Litter Invertebrates		
		Earthworm	Will & Suter, 1995
		Microbes and Microbial Processes	
	Phytotoxicity (Plants)	Soil Based Benchmark	Will & Suter, 1995

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EPA, 1993c Sediment Quality Criteria for the Protection of Benthic Organisms: Endrin. EPA-822-R-93-016. Washington D.C.

EPA, 1993d Sediment Quality Criteria for the Protection of Benthic Organisms: Fluoranthene. EPA-822-R-93-012. Washington D.C.

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Summary Table 6. ERA Benchmarks – Abiotic Media

Chemical	Surface Water mg/l	Ground Water mg/l	Sediment mg/kg	Soil mg/kg
Volatile Organic Compounds				
Acetone	1.5		0.008700	1000
Acrylonitrile				
Benzene	0.13		0.162000	
Bromoform				
2-Butanone (MEK)				
Carbon tetrachloride	0.0098		0.047600	1000
Chlorobenzene	0.064		0.417000	40
Chloroform	0.028		0.099400	
Dibromochloromethane				
1,2-Dichlorobenzene	0.014		0.332000	
1,3-Dichlorobenzene	0.071		1.682000	
1,4-Dichlorobenzene	0.015		0.347000	20
1,1-Dichloroethane	0.047		0.027200	
1,2-Dichloroethane	0.91		0.255000	
1,1-Dichloroethylene	0.025		0.312000	
cis-1,2-Dichloroethylene	0.59		0.400000	
trans-1,2-Dichloroethylene	0.59			
1,2-Dichloropropane				700
1,3-Dichloropropene	0.000055		0.000050	
Ethylbenzene	0.0073		0.089700	
Ethylene dibromide (EDB)				
Methyl-tert-butyl-ether (MTBE)				
Methyl isobutyl ketone (MIBK)	18.71			
Methylene chloride	2.2		0.375000	
Styrene		10		300
1,1,1,2-Tetrachloroethane				
1,1,2,2-Tetrachloroethane	0.61		1.372000	
Tetrachloroethylene	0.048	10	0.416000	
Toluene	0.0098	10	0.049800	200
1,1,1-Trichloroethane	0.011	100	0.030300	
1,1,2-Trichloroethane	1.2		1.251000	
Trichloroethylene	0.022		0.218000	
Vinyl chloride	0.078			
Xylenes	0.013	100	0.156000	
Semivolatile Organic Compounds				
Acenapthene	0.023	0.1	0.006710	20
Acenaphthylene			0.005870	
Anthracene	0.00073		0.046900	
Benzo(a)anthracene	0.000027		0.109000	
Benzo(b)fluoranthene				
Benzo(k)fluoranthene				
Benzo(ghi)perylene				

Chemical	Surface Water mg/l	Ground Water mg/l	Sediment mg/kg	Soil mg/kg
Benzo(a)pyrene	6.70e-06		0.088800	
Benzidine	0.0039		0.001680	
Bis(2-chloroethoxy)methane				
Bis(2-chloroethyl)ether				
Bis(2-chloroisopropyl)ether				
Bis (2-ethyl hexyl)phthalate	7.593e-07		0.182000	
4-Bromophenyl phenyl ether	0.0015		1.241000	
Butyl benzyl phthalate	0.019		10.946000	
2-Chloronapthalene				
2-Chlorophenol				
4-Chlorophenyl phenyl ether			0.108000	
Chrysene				
m-cresol				
o-cresol	58.07			
p-cresol				
Dibenzo(a,h)anthracene			0.006220	
Di-n-butyl phthalate	0.0001502		11.981000	200
Di-n-octyl phthalate				
3,3'-Dichlorobenzidine				
2,4-Dichlorophenol				20
Diethyl phthalate	0.21	20	0.606000	100
Dimethyl phthalate				200
2,4-Dinitrotoluene				
2,6-Dinitrotoluene				
Di-n-octyl phthalate				
Fluoranthene	0.00616		0.113000	
Fluorene	0.0039		0.019000	30
Hexachloroethane	0.012		1.032000	
Hexachlorobenzene				1000
Hexachlorobutadiene				
Hexachlorocyclopentadiene		0.1		10
Indeno(1,2,3-c,d) pyrene				
Isophorone				
Naphthalene	0.012	10	0.034600	
Nitrobenzene		8		40
N-Nitroso di-n-propylamine				
N'Nitroso di-n-phenylamine	0.21			20
Pentachlorophenol	0.000275	0.03		3
Phenanthrene	0.0063		0.086700	
Phenol	0.001	10	0.032000	30
Pyrene			0.153000	
Pyridine				
1,2,4-Trichlorobenzene	0.11		9.683000	
2,4,5-Trichlorophenol				9
2,4,6-Trichlorophenol				10

Chemical	**Surface Water mg/l**	**Ground Water mg/l**	**Sediment mg/kg**	**Soil mg/kg**
PAH, Total LMW			0.312000	
PAH, Total HMW			0.655000	
PAH, Total			1.022000	
Inorganic Compounds				
Aluminum	0.018	0.02	2.000000	50
Ammonia	0.72			
Antimony	0.03			5
Arsenic (total)	0.016	0.001	6.000000	10
Barium	0.004			500
Beryllium	0.00066	0.5		10
Cadmium	0.0002307	0.1	0.600000	3
Chromium (total)	3.593	0.05	26.000000	0.4
Chromium, trivalent	0.12			
Chromium, hexavalent	0.011			
Copper	0.0029	0.05	16.000000	50
Cyanide	0.001			
Iron	1		0.020000	10
Lead	0.0013	0.02	30.200000	50
Mercury (inorganic)	4.527e-07	0.005	0.130000	0.1
Mercury (methyl)	2.80e-06	0.0002		
Nickel (soluble salts)	0.0083	0.5	15.900000	30
Selenium	0.0002363	0.7		1
Silver	0.00036	0.1	0.730000	2
Sodium	1.5			
Thallium	0.001	0.02		1
Vanadium	0.02	0.2		2
Zinc	0.0123	0.4	120.000000	50
Pesticides and PCBs				
Alachlor				
Aldicarb				
Aldrin	1.00e-06		0.002000	
Atrazine				
BHC – delta	3.97e-07		0.003000	
Chlordane	8.89e-06		0.000500	
4,4'-DDD	0.011		0.001220	
4,4'-DDE			0.002070	
4,4'-DDT	4.136e-09		0.001190	
DDT, Total			0.000700	
Dieldrin	1.3652e-06		0.000020	
Endosulfan			0.005000	
Endosulfan – alpha	0.001			
Endosulfan – beta	0.001			
Endosulfan sulfate	0.051			
Endrin	1.313e-06		0.000020	
2-4 D				

Chemical	Surface Water mg/l	Ground Water mg/l	Sediment mg/kg	Soil mg/kg
Heptachlor epoxide	3.60e-06		0.005000	
Heptachlor	1.083e-06		0.068000	
Lindane (BHC-gamma)	0.00008		0.000320	
Methoxychlor	0.000019		0.018800	
Toxaphene	2.00e-07			
PCBs	0.00014		0.021600	40
Arochlor 1016	0.000014		0.007000	
Arochlor 1221	0.000014		0.602000	
Arochlor 1232	0.000014		0.170000	
Arochlor 1242	4.65e-06		1.014000	
Arochlor 1248	1.90e-07		0.030000	
Arochlor 1254	1.90e-07		0.060000	
Arochlor 1260	0.000014		0.005000	
Dioxins/Furans				
TCDD				
Dioxins	2.134e-11			
Furans	4.30e-06	100		600
Dibenzofuran	0.0037		0.418000	

Table 7. ERA Benchmarks and Water Quality Benchmarks (BM) – Aquatic Life Chronic Toxicity and Wildlife Water Based Benchmarks (BM)

Chemical	Freshwater Criteria	Ref. Notes	Fresh-water BM	Ref Notes	Marine Criteria	Ref. Notes	Marine BM	Ref. Notes	Wildlife mg/l
Volatile Organic Compounds									
Acetone			1.5	OR					33.2
Acrylonitrile									
Benzene			0.13	OR					2.293
Bromoform									
2-Butanone (MEK)									
Carbon tetrachloride			0.0098	OR					0.913
Chlorobenzene			0.064	OR					
Chloroform			0.028	OR					3.439
Dibromochloromethane									
1,2-Dichlorobenzene			0.014	OR					
1,3-Dichlorobenzene			0.071	OR					
1,4-Dichlorobenzene			0.015	OR					
1,1-Dichloroethane			0.047	OR					
1,2-Dichloroethane			0.91	OR					4.284
1,1-Dichloroethylene			0.025	OR					0.929
1,2-Dichloroethylene			0.59	OR					6.197
1,2-Dichloropropane									
1,3-Dichloropropene			0.055	OR					
Ethylbenzene			0.0073	OR					
Ethylene dibromide (EDB)									
Methyl-tert-butyl-ether (MTBE)									
Methyl isobutyl ketone (MIBK)									18.71
Methylene chloride			2.2	OR					3.99
Styrene									
1,1,1,2-Tetrachloroethane									
1,1,2,2-Tetrachloroethane			0.61	OR					
Tetrachloroethylene			0.098	OR					0.048
Toluene			0.0098	OR					0.764
1,1,1-Trichloroethane			0.011	OR					49.42
1,1,2-Trichloroethane			1.2	OR					
Trichloroethylene			0.047	OR					0.022
Vinyl chloride									0.078
Xylenes			0.013	OR					0.028
Semivolatile Organic Compounds									
Acenapthene	0.023	N							
Acenaphthylene									

Chemical	Freshwater Criteria	Ref. Notes	Fresh-water BM	Ref Notes	Marine Criteria	Ref. Notes	Marine BM	Ref. Notes	Wildlife mg/l
Anthracene			0.0073	OR					
Benzo(a)anthracene			0.000027	OR					
Benzo(b)fluoranthene									
Benzo(k)fluoranthene									
Benzo(ghi)perylene									
Benzo(a)pyrene			0.000014	OR					6.70e-06
Benzidine			0.0039	OR					0.188
Bis(2-chloroethoxy)methane									
Bis(2-chloroethyl)ether									
Bis(2-chloroisopropyl)ether									
Bis (2-ethyl hexyl)phthalate			0.003	OR					7.593e-07
4-Bromophenyl phenyl ether			0.0015	OR					
Butyl benzyl phthalate			0.019	OR					
2-Chloronapthalene									
2-Chlorophenol									
4-Chlorophenyl phenyl ether									
Chrysene									
m-cresol									
o-cresol									58.07
p-cresol									
cresols									
Dibenzo(a,h)anthracene									
Di-n-butyl phthalate			0.035	OR					0.0001502
Di-n-octyl phthalate									
3,3'-Dichlorobenzidine									
2,4-Dichlorophenol									
Diethyl phthalate			0.21	OR					210.561
Dimethyl phthalate									
2,4-Dinitrotoluene									
2,6-Dinitrotoluene									
Di-n-octyl phthalate									
Fluoranthene	0.00616	N							
Fluorene			0.0039	OR					
Hexachloroethane			0.012	OR					
Hexachlorobenzene									
Hexachlorobutadiene									
Hexachlorocyclopentadiene									

Chemical	Freshwater Criteria	Ref. Notes	Fresh-water BM	Ref Notes	Marine Criteria	Ref. Notes	Marine BM	Ref. Notes	Wildlife mg/l
Indeno(1,2,3-c,d) pyrene									
Isophorone									
Naphthalene			0.012	OR					
Nitrobenzene									
N-Nitroso di-n-propylamine									
N'Nitroso di-n-phenylamine			0.21	OR					
Pentachlorophenol	0.00573	CT			0.0079	CT			0.000275
Phenanthrene	0.0063	N							
Phenol	0.11	GL							
Pyrene									
Pyridine									
1,2,4-Trichlorobenzene			0.11	OR					
2,4,5-Trichlorophenol									
2,4,6-Trichlorophenol									
Inorganic Compounds									
Aluminum	0.087	N							0.018
Ammonia	1.43	CT			0.72	CT			
Antimony			0.03	OR					0.161
Arsenic (total)	0.19	CT			36	CT			0.016
Barium			0.004	OR					23.1
Beryllium			0.00066						
Cadmium	0.00062	CT			0.0093	CT			0.0002307
Chromium (total)									3.593
Chromium, trivalent	0.103	CT							
Chromium, hexavalent	0.01	CT			0.5	CT			
Copper	0.0048	CT			0.0024	CT			0.213
Cyanide	0.0052	CT			0.001	CT			276.6
Iron	1	N							
Lead	0.0012	CT			0.0081	CT			0.049
Mercury (inorganic)	0.012	CT			0.025	CT			4.527e-07
Mercury (methyl)			2.80e-06	OR					
Nickel (soluble salts)	0.088	CT			0.0083	CT			1.438
Selenium	0.005	CT			0.071	CT			0.0002363
Silver			0.00036	OR					
Sodium			1.5	OR					
Thallium			0.012	OR					0.001

Chemical	Freshwater Criteria	Ref. Notes	Fresh-water BM	Ref Notes	Marine Criteria	Ref. Notes	Marine BM	Ref. Notes	Wildlife mg/l
Vanadium			0.02	OR					0.835
Zinc	0.0582	CT			0.081	CT			0.03
Pesticides and PCBs									
Alachlor									
Aldicarb									
Aldrin	0.0015	CT, A			0.00065	CT, A			1.000e-06
Atrazine									
BHC - delta			0.0022	OR					3.970e-07
Chlordane	4.30e-06	CT			4.00e-06	CT			8.890e-06
4,4'-DDD			0.000011	OR					
4,4'-DDE									
4,4'-DDT	1.00e-06	CT	0.000013	EPA Sed	1.00e-06	CT			4.136e-09
Dieldrin	1.90e-06	CT	0.000062		1.90e-06	CT			1.365e-06
Endosulfan - alpha	5.60e-06	CT			8.70e-06	CT			0.001
Endosulfan - beta	5.60e-06	CT			8.70e-06	CT			0.001
Endosulfan sulfate									
Endrin	2.30e-06	CT	0.000061	OR	2.30e-06	CT			1.313e-06
2-4 D									
Heptachlor epoxide	3.80e-06	CT			3.60e-06	CT			
Heptachlor	3.80e-06	CT			3.60e-06	CT			1.083e-06
Lindane (BHC-gamma)	0.00008	CT							0.009
Methoxychlor			0.000019	OR					0.001
Toxaphene	2.00e-07	CT			2.00e-07	CT			0.001
PCBs			0.00014	OR					
Arochlor 1016	0.014	CT			0.00003	CT			0.000092
Arochlor 1221	0.014	CT	0.00028	OR	0.00003	CT			
Arochlor 1232	0.014	CT	0.00058	OR	0.00003	CT			
Arochlor 1242	0.014	CT	0.0000	OR	0.00003	CT			4.650e-

Chemical	Freshwater Criteria	Ref. Notes	Fresh-water BM	Ref Notes	Marine Criteria	Ref. Notes	Marine BM	Ref. Notes	Wildlife mg/l
			53						06
Arochlor 1248	0.014	CT	0.0000 81	OR	0.00003	CT			1.900e-07
Arochlor 1254	0.014	CT	0.0000 33	OR	0.00003	CT			1.900e-07
Arochlor 1260	0.014	CT	0.0004	OR	0.00003	CT			
Dioxins/Furans									
TCDD									
Dioxins									2.134e-11
Furans									4.300e-06
Dibenzofuran			0.0037	OR					

KEY

CT: Connecticut Water Quality Criteria
A: Based on Acute Toxicity
GL: EPA Great Lakes Program
N: EPA Water Quality Criteria
OR: Oak Ridge National Laboratory (Suter & Tsao, 1996)

Note: The Wildlife benchmarks are taken from Sample et al 1996 and represent the most restrictive of the drinking water and pisicorous based benchmarks contained therein.

Table 8. ERA Benchmarks and Sediment Quality Benchmarks – mg/kg

Chemical	EPA SQC	EqP SQB	Basis	NOAA ER-L	ER-M	FDEP TEL	PEL	OME LEL	SEL
Volatile Organic Compounds									
Acetone		0.0087	OR						
Acrylonitrile									
Benzene		0.162	OR						
Bromoform									
2-Butanone (MEK)									
Carbon tetrachloride		0.0476	OR						
Chlorobenzene		0.417	OR						
Chloroform		0.0994	OR						
Dibromochloromethane									
1,2-Dichlorobenzene		0.332	OR						
1,3-Dichlorobenzene		1.682	OR						
1,4-Dichlorobenzene		0.347	OR						
1,1-Dichloroethane		0.0272	OR						
1,2-Dichloroethane		0.255	OR						
1,1-Dichloroethylene		0.312	OR						
1,2-Dichloroethylene		0.4	OR						
1,2-Dichloropropane									
1,3-Dichloropropene		0.00005	OR						
Ethylbenzene		0.0897	OR						
Ethylene dibromide (EDB)									
Methyl-tert-butyl-ether (MTBE)									
Methyl isobutyl ketone (MIBK)									
Methylene chloride		0.375	OR						
Styrene									
1,1,1,2-Tetrachloroethane									
1,1,2,2-Tetrachloroethane		1.372	OR						
Tetrachloroethylene		0.416	OR						
Toluene		0.0498	OR						
1,1,1-Trichloroethane		0.0303	OR						
1,1,2-Trichloroethane		1.251	OR						
Trichloroethylene		0.218	OR						
Vinyl chloride									
Xylenes		0.156	OR						
Semivolatile Organic Compounds									
Acenapthene	1.3			0.016	0.5	0.00671	0.0889		
Acenaphthylene				0.044	0.64	0.00587	0.128		
Anthracene		0.218	OR	0.0853	1.1	0.0469	0.245		

Chemical	EPA SQC	EqP SQB	Basis	NOAA ER-L	ER-M	FDEP TEL	PEL	OME LEL	SEL
Benzo(a)anthracene		0.109	OR	0.261	1.6	0.748	0.693		
Benzo(b)fluoranthene									
Benzo(k)fluoranthene									
Benzo(ghi)perylene									
Benzo(a)pyrene		0.143	OR	0.43	1.6	0.0888	0.763		
Benzidine		0.00168	OR						
Bis(2-chloroethoxy)methane									
Bis(2-chloroethyl)ether									
Bis(2-chloroisopropyl)ether									
Bis (2-ethyl hexyl)phthalate		892.732	N			0.182	2.647		
4-Bromophenyl phenyl ether		1.241	OR						
Butyl benzyl phthalate		10.946	OR						
2-Chloronapthalene									
2-Chlorophenol									
4-Chlorophenyl phenyl ether				0.354	2.8	0.108	0.846		
Chrysene									
m-cresol									
o-cresol									
p-cresol									
Cresols									
Dibenzo(a,h)anthracene				0.0634	0.26	0.00622	0.135		
Di-n-butyl phthalate		11.981	OR						
Di-n-octyl phthalate									
3,3'-Dichlorobenzidine									
2,4-Dichlorophenol									
Diethyl phthalate		0.606	OR						
Dimethyl phthalate									
2,4-Dinitrotoluene									
2,6-Dinitrotoluene									
Di-n-octyl phthalate									
Fluoranthene	6.2			0.6	5.1	0.113	1.494		
Fluorene		0.54	OR	0.019	0.54	0.0212	0.144		
Hexachloroethane		1.032	OR						
Hexachlorobenzene									
Hexachlorobutadiene									
Hexachlorocyclopentadiene									

Chemical	EPA SQC	EqP SQB	Basis	NOAA ER-L	ER-M	FDEP TEL	PEL	OME LEL	SEL
Indeno(1,2,3-c,d) pyrene									
Isophorone									
Naphthalene		0.242	OR	0.16	2.1	0.0346	0.391		
Nitrobenzene									
N-Nitroso di-n-propylamine									
N'Nitroso di-n-phenylamine									
Pentachlorophenol									
Phenanthrene	1.8			0.24	1.5	0.0867	0.544		
Phenol		0.032	OR						
Pyrene				0.665	2.6	0.153	1.398		
Pyridine									
1,2,4-Trichlorobenzene		9.683	OR						
2,4,5-Trichlorophenol									
2,4,6-Trichlorophenol									
PAH, Total LMW				0.552	3.16	0.312	1.442		
PAH, Total HMW				1.7	9.6	0.655	6.676		
PAH, Total				1.022	44.792	1.684	16.77	2	110
Inorganic Compounds									
Aluminum				2	25				
Ammonia									
Antimony									
Arsenic (total)				8.2	70	7.24	41.6	6	33
Barium									
Beryllium									
Cadmium				1.2	9.6	0.68	4.21	0.6	10
Chromium (total)				81	370	52.3	160	26	110
Chromium, trivalent									
Chromium, hexavalent									
Copper				34	270	18.7	108	16	110
Cyanide									
Iron								2%	4%
Lead				46.7	218	30.2	112	31	250
Mercury (inorganic)				0.15	0.71	0.13	0.7	0.2	2
Mercury (methyl)									
Nickel (soluble salts)				20.9	51.6	15.9	42.8	16	75
Selenium									

Chemical	EPA SQC	EqP SQB	Basis	NOAA ER-L	ER-M	FDEP TEL	PEL	OME LEL	SEL
Silver				1	3.7	0.73	1.77		
Sodium									
Thallium									
Vanadium									
Zinc				150	410	124	271	120	820
Pesticides and PCBs									
Alachlor									
Aldicarb									
Aldrin								0.002	0.08
Atrazine									
BHC - delta		0.12	OR					0.003	0.12
Chlordane		2.79	OR	0.0005	0.006	0.00226	0.00479	0.007	0.06
4,4'-DDD		0.11	OR			0.00122	0.00781	0.008	0.06
4,4'-DDE				0.0022	0.027	0.00207	0.00374	0.005	0.19
4,4'-DDT		0.343	OR			0.00119	0.00477		
DDT Total				0.00158	0.0461	0.00389	0.0517	0.0007	0.12
Dieldrin	0.11			0.00002	0.008	0.00072	0.0043	0.002	0.91
Endosulfan		0.005	OR						
Endosulfan sulfate									
Endrin	0.042			0.00002	0.045			0.003	1.3
2-4 D									
Heptachlor epoxide								0.005	0.05
Heptachlor		0.068	OR						
Lindane (BHC-gamma)		0.00374	OR			0.00032	0.00099	0.003	0.01
Methoxychlor		0.0188	OR						
Toxaphene									
PCBs				0.0227	0.18	0.0216	0.189	0.07	5.3
Arochlor 1016		0.118	OR					0.007	0.53
Arochlor 1221		0.602	OR						
Arochlor 1232		0.17	OR						
Arochlor 1242		1.014	OR						
Arochlor 1248		0.814	OR					0.03	1.5
Arochlor 1254		4574.3	OR					0.06	0.34
Arochlor 1260								0.005	0.24

Chemical	EPA SQC	EqP SQB	Basis	NOAA ER-L	ER-M	FDEP TEL	PEL	OME LEL	SEL
Dioxins/Furans									
TCDD									
Dioxins									
Furans									
Dibenzofuran		0.418	OR						

Table 9. ERA Benchmarks and Soil Quality Benchmarks – mg/kg

Chemical	Earthworms	Microorgs Mibrobes
Volatile Organic Compounds		
Acetone		1000
Acrylonitrile		
Benzene		
Bromoform		
2-Butanone (MEK)		
Carbon tetrachloride		1000
Chlorobenzene	40	
Chloroform		
Dibromochloromethane		
1,2-Dichlorobenzene		
1,3-Dichlorobenzene		
1,4-Dichlorobenzene	20	
1,1-Dichloroethane		
1,2-Dichloroethane		
1,1-Dichloroethylene		
1,2-Dichloroethylene		
1,2-Dichloropropane	700	
1,3-Dichloropropene		
Ethylbenzene		
Ethylene dibromide (EDB)		
Methyl-tert-butyl-ether (MTBE)		
Methyl isobutyl ketone (MIBK)		
Methylene chloride		
Styrene		
1,1,1,2-Tetrachloroethane		
1,1,2,2-Tetrachloroethane		
Tetrachloroethylene		
Toluene		
1,1,1-Trichloroethane		
1,1,2-Trichloroethane		
Trichloroethylene		
Vinyl chloride		
Xylenes		
Semivolatile Organic Compounds		
Acenapthene	20	
Acenaphthylene		
Anthracene		

Chemical	Earthworms	Microorgs Mibrobes
Benzo(a)anthracene		
Benzo(b)fluoranthene		
Benzo(k)fluoranthene		
Benzo(ghi)perylene		
Benzo(a)pyrene		
Benzidine		
Bis(2-chloroethoxy)methane		
Bis(2-chloroethyl)ether		
Bis(2-chloroisopropyl)ether		
Bis (2-ethyl hexyl)phthalate		
4-Bromophenyl phenyl ether		
Butyl benzyl phthalate		
2-Chloronapthalene		
2-Chlorophenol		
4-Chlorophenyl phenyl ether		
Chrysene		
m-cresol		
o-cresol		
p-cresol		
Cresols		
Dibenzo(a,h)anthracene		
Di-n-butyl phthalate		
Di-n-octyl phthalate		
3,3'-Dichlorobenzidine		
2,4-Dichlorophenol		
Diethyl phthalate		
Dimethyl phthalate	200	
2,4-Dinitrotoluene		
2,6-Dinitrotoluene		
Di-n-octyl phthalate		
Fluoranthene		
Fluorene	30	
Hexachloroethane		
Hexachlorobenzene		1000
Hexachlorobutadiene		
Hexachlorocyclopentadiene		
Indeno(1,2,3-c,d) pyrene		
Isophorone		
Naphthalene		

Chemical	Earthworms	Microorgs Mibrobes
Nitrobenzene	40	1000
N-Nitroso di-n-propylamine		
N'Nitroso di-n-phenylamine	20	
Pentachlorophenol	4	400
Phenanthrene		
Phenol	30	100
Pyrene		
Pyridine		
1,2,4-Trichlorobenzene		
2,4,5-Trichlorophenol		9
2,4,6-Trichlorophenol		10
PAH, Total LMW		
PAH, Total HMW		
PAH, Total		
Inorganic Compounds		
Aluminum		600
Ammonia		
Antimony		
Arsenic (total)	60	100
Barium		3000
Beryllium		
Cadmium	20	20
Chromium (total)	0.4	10
Chromium, trivalent		
Chromium, hexavalent		
Copper	50	100
Cyanide		
Iron		200
Lead	500	900
Mercury (inorganic)	0.1	30
Mercury (methyl)		
Nickel (soluble salts)	200	90
Selenium	70	100
Silver		50
Sodium		
Thallium		
Vanadium		20
Zinc	200	100

Chemical	Earthworms	Microorgs Mibrobes
Pesticides and PCBs		
Alachlor		
Aldicarb		
Aldrin		
Atrazine		
BHC - delta		
Chlordane		
4,4'-DDD		
4,4'-DDE		
4,4'-DDT		
Dieldrin		
Endosulfan - alpha		
Endosulfan - beta		
Endosulfan sulfate		
Endrin		
2-4 D		
Heptachlor epoxide		
Heptachlor		
Lindane (BHC-gamma)		
Methoxychlor		
Toxaphene		
PCBs		
Arochlor 1016		
Arochlor 1221		
Arochlor 1232		
Arochlor 1242		
Arochlor 1248		
Arochlor 1254		
Arochlor 1260		
Dioxins/Furans		
TCDD		
Dioxins		
Furans		
Dibenzofuran		

Table 10. ERA Benchmarks and Plant Protection Benchmarks

Chemical	Soil mg/kg	Solution mg/l
Volatile Organic Compounds		

Chemical	Soil mg/kg	Solution mg/l
Acetone		
Acrylonitrile		
Benzene		
Bromoform		
2-Butanone (MEK)		
Carbon tetrachloride		
Chlorobenzene		
Chloroform		
Dibromochloromethane		
1,2-Dichlorobenzene		
1,3-Dichlorobenzene		
1,4-Dichlorobenzene		
1,1-Dichloroethane		
1,2-Dichloroethane		
1,1-Dichloroethylene		
cis-1,2-Dichloroethylene		
trans-1,2-Dichloroethylene		
1,2-Dichloropropane		
1,3-Dichloropropene		
Ethylbenzene		
Ethylene dibromide (EDB)		
Methyl-tert-butyl-ether (MTBE)		
Methyl isobutyl ketone (MIBK)		
Methylene chloride		
Styrene	300	10
1,1,1,2-Tetrachloroethane		
1,1,2,2-Tetrachloroethane		
Tetrachloroethylene		10
Toluene	200	10
1,1,1-Trichloroethane		100
1,1,2-Trichloroethane		
Trichloroethylene		
Vinyl chloride		
Xylenes		100
Semivolatile Organic Compounds		
Acenapthene	20	0.1
Acenaphthylene		
Anthracene		
Benzo(a)anthracene		

Chemical	Soil mg/kg	Solution mg/l
Benzo(b)fluoranthene		
Benzo(k)fluoranthene		
Benzo(ghi)perylene		
Benzo(a)pyrene		
Benzidine		
Bis(2-chloroethoxy)methane		
Bis(2-chloroethyl)ether		
Bis(2-chloroisopropyl)ether		
Bis (2-ethyl hexyl)phthalate		
4-Bromophenyl phenyl ether		
Butyl benzyl phthalate		
2-Chloronapthalene		
2-Chlorophenol		
4-Chlorophenyl phenyl ether		
Chrysene		
m-cresol		
o-cresol		
p-cresol		
Cresols		
Dibenzo(a,h)anthracene		
Di-n-butyl phthalate	200	
Di-n-octyl phthalate		
3,3'-Dichlorobenzidine		
2,4-Dichlorophenol	20	
Diethyl phthalate	100	20
Dimethyl phthalate		
2,4-Dinitrotoluene		
2,6-Dinitrotoluene		
Di-n-octyl phthalate		
Fluoranthene		
Fluorene		
Hexachloroethane		
Hexachlorobenzene		
Hexachlorobutadiene		
Hexachlorocyclopentadiene	10	0.1
Indeno(1,2,3-c,d) pyrene		
Isophorone		
Naphthalene		10

Chemical	Soil mg/kg	Solution mg/l
Nitrobenzene		8
N-Nitroso di-n-propylamine		
N'Nitroso di-n-phenylamine		
Pentachlorophenol	3	0.03
Phenanthrene		
Phenol	70	10
Pyrene		
Pyridine		
1,2,4-Trichlorobenzene		
2,4,5-Trichlorophenol		
2,4,6-Trichlorophenol		
PAH, Total LMW		
PAH, Total HMW		
PAH, Total		
Inorganic Compounds		
Aluminum	50	0.02
Ammonia		
Antimony	5	
Arsenic (total)	10	0.001
Barium	500	
Beryllium	10	0.5
Cadmium	3	0.1
Chromium (total)	1	0.05
Chromium, trivalent		
Chromium, hexavalent		
Copper	100	0.05
Cyanide		
Iron	10	
Lead	50	0.02
Mercury (inorganic)	0.3	0.005
Mercury (methyl)		0.0002
Nickel (soluble salts)	30	0.5
Selenium	1	0.7
Silver	2	0.1
Sodium		
Thallium	1	0.02
Vanadium	2	0.2
Zinc	50	0.4
Pesticides and PCBs		

Chemical	Soil mg/kg	Solution mg/l
Alachlor		
Aldicarb		
Aldrin		
Atrazine		
BHC - delta		
Chlordane		
4,4'-DDD		
4,4'-DDE		
4,4'-DDT		
Dieldrin		
Endosulfan - alpha		
Endosulfan - beta		
Endosulfan sulfate		
Endrin		
2-4 D		
Heptachlor epoxide		
Heptachlor		
Lindane (BHC-gamma)		
Methoxychlor		
Toxaphene		
PCBs	40	
Arochlor 1016		
Arochlor 1221		
Arochlor 1232		
Arochlor 1242		
Arochlor 1248		
Arochlor 1254		
Arochlor 1260		
Dioxins/Furans		
TCDD		
Dioxins		
Furans	600	100
Dibenzofuran		